Organizational and technological simulation of the construction organization activity in the complex infrastructure projects implementation

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Abstract. The article discusses the construction production organizational and technological improving issues and the qualifications of specialists, which become the key factors in the investment and construction projects (ICP) management. The relevance of the study is due to the fact that the studies showed that currently main problem hindering the ICP management innovations introduction is the weak motivation and low qualification of managerial employees and their lack of teamwork skills using modern information technologies and databases.

One of the tools to improve the professional level and improve the project team coherence when managing ICP is a system that is a simulator - a simulator developed on the specialized information technology basis.

In the simulation model use a simulator can be widely used in construction for training and retraining of personnel involved in the ICP management.

The proposed methodology will allow to simulate the various options for the managerial decisions’ preparation and adoption at various stages and time intervals for the ICP implementation.

Introduction
To overcome the protracted economic stagnation in the Russian Federation, the production technological level importance and the technology carriers’ qualifications are becoming a key factor in ICP managing.

The construction organizations management system audit performed by the specialists from the Don State Technical University (DSTU) showed that along with problems such as imperfection of the pricing system, lack of effective interaction between project participants, etc. one of the main factors hindering the innovations introduction in management when managing the investment construction projects (ICPs) is the low qualification of managerial employees and their lack of teamwork skills when using modern information technologies and databases.

These conclusions coincide with the opinion of the head of one of the largest self-regulatory organizations (SROs) in the North Caucasus NP YugSevKavStroy, Doctor of Technical Sciences, prof. Mayilyan L. R, that one of the “diseases” of a number of construction company managers is an attempt to hire the “cheap” job workers willing to work at low wages, but lacking the necessary competencies in managing the construction projects.

Main Part
The American organization CURT (Construction Users Roundtable), which includes the country’s largest industrialists and entrepreneurs, recently published the following statement:

“The starting changes point is retraining of personnel and the formation of a new worldview. The goals of the Lean concept are the qualified employees, an atmosphere of mutual trust and support. The companies’ leaders should be the carriers of the changes, but they must also demand the changes from other participants in the process. The Lean concept should be adopted as a new industrial philosophy” [4].

Further training of specialists in the field of ICP management becomes especially relevant when implementing the complex infrastructure investment and construction projects, which is due to the following.

- In the field of production:
  - features of construction production (uniqueness of products, a long production cycle, stationarity and territorial fragmentation of construction objects, etc.), which requires the training of specialists who could quickly navigate and respond to the changes occurring at the construction site;
  - the constant complication of the creating building products processes due to the emergence of new building materials, technologies, equipment and increasing requirements for constructed buildings and structures by customers;
  - a reduction in the number of orders and increased competition in the contracting market, which does not allow evenly loading the production capacities of many construction organizations for a long planning period and maintaining a permanent engineering staff. This leads to the need for a short period of time, after the conclusion of the contract, to complete the project team of specialists of different profiles and prepare them for coordinated work on the ICP management;
  - the need to overcome the so-called “human factor” when introducing into the production management using information technologies of the ERP class oriented when managing ICPs on the network — collective work of specialists using a single information base and the ability to calculate key performance indicators (KPI) for almost every project participant.

- In the field of specialist training:
  - the educational process orientation to a specific set of competencies does not allow a student to form a holistic systemic flow view of the production processes and methods for managing them;
  - the student’s lack of the opportunity to complete a full-fledged production practice at large construction sites and, moreover, to obtain the necessary skills in managing the ICP leads to the fact that after graduation, when hiring a job in a construction or design organization, he is offered to work on a low-paid job, without any guarantees for additional retraining and subsequent career growth. Moreover, in many construction organizations the staff professional knowledge level is quite low and there is actually no one to learn from the newly hired employee.

- One approach to improving the professional level and improving the coherence of the project team in the ICP management is to create an interdisciplinary, project-oriented educational program for training specialists. One of the tools for implementing the “program” is a system that is a simulator, developed on the specialized information technology for ICP management basis.

- According to Haskett consulting inc. (HCI): “People remember 20% of what they see, 40% of what they see and hear, and 70% of what they see, hear and do”. [1] Therefore, a necessary element of effective training is constant training, including using a simulator

- Simulators-simulators - software or hardware-software systems that simulate real processes and situations, with the aim of training personnel, developing skills and abilities [2]. http://www.rpts.ru/ru/products/develop-ts.html

- At the Don State Technical University, an intellectual construction management system (IMS “Construction”), which is based on the ICP management methodology based on Lean technology (LIN - lean manufacturing) is being developed [3]. IMS “Construction” is implemented as part of subsystems that allow to simulate the management processes in the following functional areas, which correspond to the subsystem:
• the construction production preparation;
• the construction site operational management;
• the construction objects’ material and technical support;
• the reinforced concrete and metal products own production management;
• the machinery and mechanisms operation management;
• the ICP management accounting and budgeting
• quality management of the work performed
• Accounting.

The construction production organization and management effectiveness is characterized by the working time loss of workers and construction machines in the ICP implementation. Therefore, as a local criterion for optimizing the effectiveness of managing a construction object in the MIS “Construction”, proceeding from the Lean ideology, the cumulative level of time losses (integrally replaceable and intra-shift downtimes) that arose at the construction object z over a certain period of time has been adopted [1].

\[ U^n_z = \sum_{t=1}^{T_p} \sum_{l=1}^{L} u^p_{tiz} z \in Z \]  

where \( t \) – is a working day; \( T_P \) – is a planning period; \( L \) – defines the unproductive losses causes; \( u^p_{tiz} \) - are the downtime of workers and construction machines (non-renewable resources loss) due to \( L \) reasons on \( t \) day accordingly;

The simulator use in the ICP management will allow the students to more fully study the project management mechanism at the design and construction stages, learn how to work in a team with specialists of different profiles, and learn the working skills based on modern information Lean manufacturing technologies.

The use of a simulation model - a simulator can be widely used in construction for training and retraining of personnel involved in the ICP management.

The proposed methodology will allow to simulate various options for the managerial decisions’ preparation and adoption at various stages and time intervals for the ICP implementation. For this purpose, the software for the organizational structure adopted at a particular enterprise, is configured. The software is configured by developing the so-called workstations (WS). WS is a software and hardware complex that allows to implement the employee’s functions of a certain profile. For example, a production engineer solves the problems of planning, production accounting, construction control, etc., which are part of different subsystems. Therefore, when earning a workstation, the software is set up for those functions that are charged to a particular employee, in this case, it’s a production engineer.

Figure 1 presents three possible options for using the simulation model - a simulator in design, construction (general contracting, subcontracting) organizations and enterprises for the production of building materials, structures and products.

So, for example, to simulate the construction organization activities with a standard organizational structure when managing ICPs, a set of the following workstations is required:

• Workstation “Head of the organization”;
• Workstation “Work Producer”; 
• Workstation “Production Engineer”;
• Workstation “Material Engineer”; 
• Workstation “Economist-analytics”;
• Workstation “Estimator”;
• Workstation “Accountants”. 
To simulate the activities of a design organization:
• Workstation “Head of the organization”;
• Workstation of the “Chief Project Engineer”;
• Workstation “Chief Specialist”;
• Workstation “Designer”;
• Workstation of “Estimator-technologist”;
• Workstation ”PIC Developer”;
• Workstation “Accountants”.

To simulate the activities of enterprises in the construction industry:
• Workstation “Head of the enterprise”
• Workstation “Planner - economist”;
• Workstation “Production Engineer”;
• Workstation “Workshop Masters”;
• Workstation “Accountants”.

If the organizational structure of a particular design, construction organization or enterprise of the construction industry differs from the standard configuration, the information system is individually configured. So, for example, if a construction organization uses a lot of construction machines and mechanisms (own, rented, acquired on lease), then the “Engineer of Mechanics” workstation is included in the workstation set, etc.

The developed information system for simulating ICP management can be integrated with the customer-builder management systems and various specialized information technologies, for example, a system of three-dimensional modeling of buildings and structures (REVIT), accounting (1C “Accounting”), etc.

An important simulator element is information support, which involves the creation of a regional information base for the construction market; project databases - analogues for various types of construction; characteristics of construction organizations, on the basis of which it is supposed to imitate the processes of implementation of one or another ICP.

The project database or its analogue consists of information grouped according to a hierarchically organized system of finding out the construction object. The main element of this system is the structural

**Figure 1.** The construction complex enterprises simulation modeling system in the investment and construction projects management
element by which all the primary information that characterizes both the design stage and construction is grouped. At the design stage, the design and working documentation is “linked” to the structural element (drawings, specifications, results of strength calculations, estimated fragments, etc.). And at the construction stage, executive documentation and documents characterizing: actual labor costs of workers (time sheets time worked), construction machines and mechanisms (Construction Machines and Mechanics work logs), material resources (consignment notes, acts of writing off the material resources), etc.

In the simulation process, the student is invited to use the project-analogue for the type of construction and technology of the object construction that interests him, which sets: the place and time of its construction and (or) design, the planning interval at which the activities of the enterprise or the organization involved in the implementation of this ICP are carried out. These parameters can be determined both by the student and the teacher. During the simulation, the student conducts the construction market marketing research in the place indicated in the task (geographical point) in order to develop the most optimal logistic scheme for the material resources supply to the construction site. Simulation may include solving management problems in all or several of the functional areas described above.

Summary
To date, we have accumulated information and created an analog objects database for a number of implemented projects and a database of the construction organizations characteristics involved in the complex infrastructure projects management.

References
[1] Chepurnenko A S, Ulianskaya V V, Yazyeva S B, Zotov I M 2018 Calculation of wooden beams on the stability of a flat bending shape enhancement (MATEC Web of Conferences) 196 01003.
[2] Chepurnenko A S, Yazyev B M, Saibel A V 2018 Calculation of orthotropic plates for creep taking into account shear deformations (MATEC Web of Conferences) 196 01002.
[3] Yazyev B M, Chepurnenko A S, Savchenko A A 2018 Calculation of Three-Layer Panels with Polyurethane Foam Filler Taking into Account the Rheological Properties of the Middle Layer (Materials Science Forum) 935 144-149.
[4] Chepurnenko A S, Neumerzhitskaya N V, Turko M S 2017 Finite Element Modeling of the Creep of Shells of Revolution Under Axisymmetric Loading (International Scientific Conference Energy Management of Municipal Transportation Facilities and Transport EMMFT 2017, Advances in Intelligent Systems and Computing) 692 808–818.
[5] Chepurnenko A S, Savchenko A A, Yazyeva S B 2017 Calculation of a three-layer plate by the finite element method taking into account the creep of the filler (MATEC Web of Conferences) 129 05008.
[6] Chepurnenko A S, Mailyan L R, Yazyev B M, Ivanov A 2017 Calculation of the rotation shells on axisymmetric load taking the creep into account (MATEC Web of Conferences) 106 04010.
[7] Yazyev S B, Kozelskaya M Yu, Strelnikov G P, Litvinov S V 2017 Energy method in solving the problems of stability for a viscoelastic polymer rods (MATEC Web of Conferences) 129 05010.
[8] Trush L, Litvinov S, Zakieva N, Bayramukov S 2017 Optimization of the Solution of a Plane Stress Problem of a Polymeric Cylindrical Object in Thermoviscoelastic Statement (International Scientific Conference Energy Management of Municipal Transportation Facilities and Transport EMMFT 2017. Advances in Intelligent Systems and Computing) 692 885-893.
[9] Litvinov S, Zhuravlev A, Bajramukov S, Yazyev S 2017 Forecasting the Strength of an Adhesive Bond Over a Long Period of Time (International Scientific Conference Energy Management of Municipal Transportation Facilities and Transport EMMFT 2017. Advances in Intelligent Systems and Computing) 692 902-907.
[10] Litvinov S V, Trush L I, Avakov A A 2017 Some features of temperature field definition in axisymmetric problems (International Conference on Industrial Engineering, Applications and
Manufacturing (ICIEAM), IEEE 1-5.

[11] Chepurnenko A S, Yazyev B M, Lapina A P, Zotov I M 2019 Calculation of the beams with corrugated wall on the bend flat shape stability (E3S Web of Conferences) 97 4067.

[12] Chepurnenko A S, Yazyev B M, Lapina A P 2018 A three-layer cylindrical shell calculation taking creep into account (Construction and Architecture) 6 (4-21) 14-18.

[13] Information on http://textarchive.ru/c-2217798-p3.html

[14] Information on http://www.rpts.ru/ru/products/develop-ts.html

[15] Information on https://ru.wikipedia.org/wiki/Lean

[16] Information on https://ru.scribd.com/document/277723574/Construction-Users-Roundtable-2004