Management in the Construction Sector Using Smart Technologies: European Experience

Liudmila Boldyrieva, Alina Chaikina, and Khanlar Ganiyev

Abstract The practical experience of European countries on use and dissemination of Smart technologies in construction were studied, which shows that to change difficult situation in the construction sector of the economy it is necessary to: firstly, actively use Smart technologies in construction; secondly, gradually reduce energy consumption in the construction and housing sectors through mass construction of energy-efficient buildings and structures; thirdly, to reconstruct the already built ones. It was established that the introduction of Smart Home system is becoming more and more relevant, which allows to make everyday life more convenient: saves energy (automatic switching off of the light); saves money (automatic switching off of heating as soon as windows open); provides the best protection for the house (automatically gives an audible alarm when the intruder enters, and warns residents by sending push messages to their smartphones). Certain advantages from the use of Smart technologies in construction were described. The characteristic of the software for architectural and construction design and preparation of construction documentation was given in the article. Systems for monitoring of architectural and construction projects and planning of construction works, design of building constructions of building's engineering systems, automated design of general purpose were analyzed by authors. Architectural and construction applications for AutoCAD and applications for design and calculation of plumbing systems were described. The characteristics of programs for calculation of building structures, design and calculations of pipelines, heat exchangers, geotechnical calculations, design of infrastructure objects were given in the article.

Keywords Construction · Construction sector · Efficiency · Energy efficiency · Development · Smart technologies · Management

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1 Introduction

EU countries actively use Smart technologies because they increase efficiency, reduce costs, generate new sources of income, improve the daily lives of population, and most importantly, accelerate construction and development of the construction sector. In time, the most progressive cities in Europe are following the Smart path of development.

Effective Smart technologies change the preparation and maintenance of construction projects, as well as the subsequent operation of infrastructure.

Development is gaining momentum thanks to artificial intelligence (AI), IoT gadgets for the home and 5G (fifth generation of telecommunications standards). In turn, 5G provides high data rates in unmanned vehicles, virtual reality and innovative urban infrastructures. 5G also allows the implementation of services such as "Smart" parking, smart meters, CCTV cameras, traffic management, waste control and coordination of emergency services. The next stage in the development of the construction of "Smart" homes will be more accessible through the development of this technology all over the world.

According to McKinsey & Company, the construction sector is one of the least digitized sectors of the economy. In the world in the construction sector, the cost of Smart technologies does not exceed 1%.

2 An Overview of the Latest Sources of Research and Publications

Jinying Xu and Weisheng Lu from the University of Hong Kong [1, p. 157] are convinced that the current management of the life cycle of construction projects suffered from the dilemma of "lack of information" and "explosion of information". They developed and proposed the use of a closed life cycle management system that provides a constant flow of information for all stakeholders. Matej Štefanič and Vlado Stankovski make a review of technologies and applications for Smart construction. In his publication [2, p. 83] they concluded that new opportunities in construction are possible through the Internet of Things (IoT), artificial intelligence (AI) and cloud computing technologies (CT), which monitor construction, site management, occupational safety, early warning about natural disasters, resource and asset management. After all, IoT, AI and CT offer new opportunities for the development of new intelligent applications in the construction sector. The authors are convinced that they stimulate a new wave of affordable, reliable, secure and efficient Smart applications that provide various benefits, including efficient logistics and safe working conditions. Although Matej Štefanič and Vlado Stankovski [2, pp. 83–84] focus on construction, their findings may also relate to the wider context, namely Industrie 4.0, cities, communities, civil engineering, and smart homes, transport, etc.

Authors: Yuhan Niu, Weisheng Lu, Ke Chen, George G. Huang [3] investigated intelligent construction objects (ICO), the main building blocks of future construction, which are in the stage of rapid development. ICO includes construction resources: machines, devices and materials that are "Smart" with the help of appropriate technologies that ensure effective decision-making in construction, autonomy.

The conclusions and proposals of Phil Purnell and Ming K. Lim are interesting [4, p. 223], as they tried to answer the question of the use of Smart technologies in enabling construction components reuse.

The team of authors: Guerriero Annie, Kubicki Sylvain, Berroir Fabrice and Lemaire Clément [5] at the scientific conference Funchal, Portugal offered their own research on BIM-enhanced collaborative Smart technologies for LEAN construction processes.

Boton C., Kubicki S. and. Halin G. [6] carried out research in the direction of 4D/BIM Simulation for Preconstruction and Construction Scheduling.

There is reason to believe that Smart technologies have improved life in Ukraine's cities, and helped authorities to work more efficiently. It should be noted that the first steps in the transition to an effective strategy for smart cities formation have already been made in Ukraine. Cities such as Kyiv, Lviv, Kharkiv, Vinnytsia, Chernivtsi, Dnipro are active initiators of the introduction of effective Smart technologies and digital services.

The purpose of the research is to study the European experience in managing efficient Smart technologies in the construction sector and to develop practical recommendations for its improvement in Ukraine.

The theoretical and methodological basis of scientific research is a dialectical method of scientific knowledge, a systematic approach, provisions of modern economic theory, scientific works of economists who deal with problems related to the management of effective Smart technologies in the construction sector.

Scientific research is based on the use of general scientific methods, namely: theoretical generalization, system analysis and synthesis, abstraction and formalization.

3 Main Results of the Research

Hypothetically, it can be argued that the construction and operation of buildings is one of the most energy-intensive sectors of any country economy. Thus, in some EU countries, buildings and structures consume about 30% of all energy in the country.

The practical experience of the EU countries shows that to change the difficult situation in the construction sector of the economy it is necessary: firstly, actively use Smart technologies in construction; secondly, gradually reduce energy consumption in the construction and housing sectors through mass construction of energy-efficient buildings and structures; thirdly, thirdly, to reconstruct the already built ones.

Ideally, an energy-efficient house is a virtually closed system: water is supplied by groundwater and rainwater, electricity and hot water are provided by solar panels,

gas is generated from sewage waste; exhaust ventilation supplies fresh air of the required temperature (heat recovery unit, and excess air heat is used to heat water).

Germany actively supports innovative heating technology, i.e. a special coating is applied to the facades of buildings, which accumulates solar energy during the day and gives it to the house at night. Systems with efficient heat exchangers, which provide warm water even in the cold season, have also become widespread.

Western European countries such as Sweden, Denmark and Norway also use technological techniques for homes to minimize or eliminate the use of external electricity.

In real time for visual monitoring and organization of work, environmental monitoring, feedback and signaling, cloud backup and demonstration of data analysis, you can use Smart technology "from head to toe" [1].

To collect data at different stages, a closed-loop life cycle management system is used for intelligent design based on the Internet of digital technologies, including such as: 3D laser scanner, drone, building information modeling (BIM), augmented reality (AR), Auto-ID, Global Positioning System (GPS), wireless sensor network (WSN), robotics, web applications and mobile digital devices.

This structure integrates the latest technologies in intelligent construction, building automation and the Internet of Things (IoT). Data is stored, shared, processed and used on a single unified platform for all stakeholders to support better decision-making and interaction throughout the project life cycle. Practitioners can use the information through a standardized interface between different programs throughout the life cycle [1].

Properly connected Internet of Things with the construction of information modeling can provide a safer, greener and more efficient building system [3].

Different degrees of operational autonomy are provided by intelligent applications, which include the use of IoT devices, such as smartphones, cameras, actuators, sensors, cars and robots. The construction of context-specific intelligent environments is supported by the advent of modular open source IoT platforms and interoperability standards, such as Open Fog Consortium [7] and Cloud Native Computing Foundation [8–13]. Using methods and tools that implement such standards, you can quickly integrate physical devices and software.

British businessman and founder of Virgin Startup Richard Branson, write in Linkedin that the construction industry is now lagging behind in the innovation race, that is why he began working with British construction company Colmore Tang, creating a powerful initiative for Constructech.

Quickly draws attention to the construction sector LEAN Management. In parallel, building information modeling (BIM) is a key approach to making project processes smoother, more transparent, and more integrated. There is a two-stage technological proposal for LEAN methods aimed at creating a BIM information system for complete management of construction processes. In the short term, on construction sites, a smart construction planner is the answer to the implantation of LEAN digital methods. A reflection of 4D/BIM methods and principles of LEAN determines the path to future LEAN/BIM IT-development [5, 11].

Smart Home systems as well becoming more and more relevant, which allows to make everyday life more comfortable and helps owner to:

– save energy (automatic switching off of light);
– save money (automatic switching off of heating as soon as windows open);
– provide the best protection of the house (automatically gives an audible alarm when the intruder enters, and warns residents by sending push messages to their smartphones).

In general, the French trust Smart Home more than, for example, the British, Americans or Austrians.

Smart-City projects are implemented in more than 20 cities in the UK, including large cities and small towns. All this took place within the framework of a single plan for digitization and automation of Great Britain, but with remarkable individual decisions for each settlement.

The "smart architecture" system is aimed, on the one hand, at improving architectural appearance of the city, and on the other, at improving physical and emotional state of citizens. Such system was created on the basis of BIM developments, technologies, management of the construction process and information supply to both customer and contractors.

Smart architectures are a universal reality and open new opportunities for the progressive development of the construction sector. It helps to create multifunctional architectural objects that unite in one complex: a residential building, shopping and entertainment halls, a fitness center, parking in a modern urban style. Such solutions will save time and effort for residents of such a complex and nearby houses.

Modern engineering solutions are used on facades, in comfort systems, as well as in automated fire safety and evacuation systems.

Also, for comfort of residents and visitors of such complexes, the "green" roof technology based on technology of the Swiss company ZinCo is widely used.

However, we should focus on certain advantages of using Smart technologies in construction, which are listed in Table 1.

Implementation of management strategy in the construction sector using Smart-technologies is interpreted (see Fig. 1).

The main sector of IT technology in the field of construction is software for the design and construction of the building, and thus—tracking the state of construction at specific stages, the so-called design systems, which aim to ensure multivariate projects through change and variation initial data, increase the quality of design, reduce number of required consumables, engineers engaged in design and construction, and funds, reduce design time.

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Table 1 Benefits of using Smart technologies in construction

Use of smart technologies	Advantages
Reduce energy consumption	Passive solar heating
	Correct use of quality materials
Monolithic construction	Provides a comfortable indoor climate (cool in the warm season, and warm in the cold)
Hinged ventilated facades	Increase heat and sound insulation
	Exterior of the building at the same time becomes beautiful and interesting
"Cold roof"	Reflect sunlight
	Reduce the temperature on the roof itself and directly in the house
	The ability to reduce energy consumption by 15%
	No air conditioner needed
	Care for the environment
"Green roof"	Plantations create shade in summer and keep warm in winter
Modern window systems (Smart windows)	Provides UV protection
	Regulate, depending on the time of day, amount of light that enters the room
	Change the level of transparency and adapt to external conditions

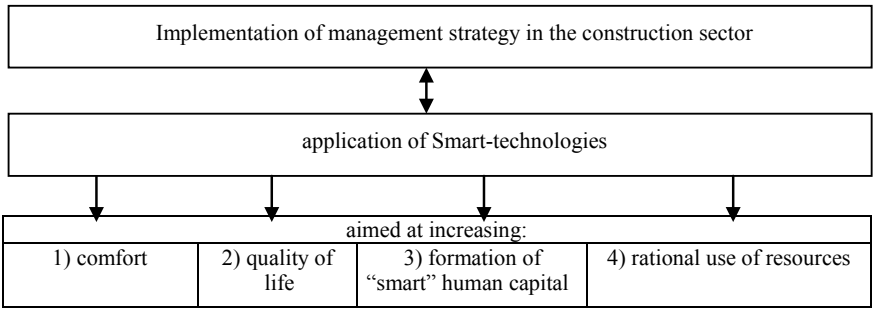

Fig. 1 Implementation of management strategy in the construction sector with the use of Smart-technologies

Software, systems, applications and programs are used for architectural design, engineering and construction calculations as shown in Table 2.

Permanent and immeasurable progress of the designed objects, modern technologies and equipment requires appearance of new and improved programs.

Table 2 Software, systems, applications and programs for architectural design, engineering and construction calculations

Software	
Software for architectural and construction design and preparation of construction documentation	Autodesk Building Design Suite; Autodesk Revit Architecture; Autodesk Factory Design Suite; Autodesk Factory Design Suite; AutoCAD Architecture
Systems for:	
Monitoring of architectural and construction projects and planning of construction works	Autodesk Navisworks
Design of building structures	Autodesk Revit Structure; Tekla Structures
Design of engineering systems of buildings	AutoCAD MEP, Revit MEP
Automated general purpose design	AutoCAD; AutoCAD LT, Autodesk 3ds MaxDesign; Std Manager CS
Applications:	
Architectural and construction applications for AutoCAD	PARCS (Parallel Asynchronous Recursively Controlled Systems), SDDC (Systems of design documentation for construction) GraphiCS
Design and calculations of plumbing systems	Plumbing designer's automated workspace, WENTSIS
Programs for:	
Calculation of building structures	SCAD Office, SCAD (Structure CAD), Comet, Kristall, Arbat, Kamin, Monolith, Section Constructor, CoKon
Design and calculations of pipelines, heat exchangers	AutoCAD Plant 3D, Autodesk Plant Design Suite, Plant 4D, START, HYDROSYSTEM, Resource, Ecolog-Shum
Geotechnical calculations	Plaxis, Plaxis Dynamics Module, Plax Flow, Plaxis 3D Tunnel, Plaxis 3D Foundation
Design of infrastructure facilities	Autodesk Civil 3D, Geoni CS

Computer-controlled software for modern construction equipment also requires appropriate software. For example, models for 3D printing, including in the field of construction, are usually distributed in STL files.

To convert a STL file to G-code (a language understood by a 3D printer), you need a "slice program" (the name is due to the fact that this program "slice" 3D model on a set of flat two-dimensional layers from which 3D printer will make physical object. Among the well-known "slicer programs" are the following: TinkerCAD, 3DTin, Sculptris, ViewSTL, Netfabb Basic, Repetier, FreeCAD, SketchUp, Simplify3D, Blender. OctoPrint and others.

Typically, required software comes bundled with a 3D printer. For example, Ultimaker and Reprap printers are equipped with Cura software, and MakerBot—MakerWare and ReplicatorG. In fact, when you buy a 3D printer, you also get licensed software "in the package". In this case, you pay in complex for equipment itself and

for the use of the relevant programs, which are the objects of intellectual property rights of specific individuals (companies), i.e. for obtaining a license.

4 Conclusion

Thus, the construction sector of Ukraine should increase the level of use Smart technologies. After all, they occupy a decisive place in the process of modern construction of EU countries.

In time, from the very beginning of design work to the implementation of Smart technology development, computer-aided design systems are widely used, which provide a variety of projects and possible verification of their condition in the future, construction and computer equipment requires appropriate information and technical support, construction of buildings within the concept of "Smart Home", as well as also need software control.

European experience proves possibility and importance of the application and dissemination of Smart technologies in construction. After all, they ensure regional development, set strategic priorities and implement intellectual policies to maximize the potential of knowledge-based development.

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