

# Construction 5.0: Examining the Challenges and Solutions Related to the Successful Implementation of the CTS with the LPS Technique of the SAAL SC in Iran's Construction Projects

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## ABSTRACT

The critical conditions of Iran's economy, especially in the construction industry, have caused this industry to move towards death or with a transformation towards greater productivity and participation. In this regard, two main approaches should be followed: new technologies and new management thinking. Industry 5.0 can facilitate this with a human-centred view of Industry 4.0. Among these Industry 4.0 tools is the control tower system, which recent scientific studies have shown to be synergistic and capable of working with the SAAL supply chain. SAAL strategy is the first strategy that was invented to exploit a chaotic environment. Positive results of their use in construction projects have been reported. However, every new approach has risks, especially since such a merger can have many risks. This study presents the results of a research project in a typical contracting company in which the control tower system was implemented with the help of LPS tools. In this research, the research topic is described, the action plan is formulated and implemented and the results are evaluated and corrected if necessary. The research results show that in successfully implementing this approach, new tools are needed to improve planning and control. Also, professionals and working people are very resistant to change. In addition, the results of the surveys show that before implementing this type of system, it is better to provide training and awareness for mental preparation. This training should be supported by resources that construction teams can use full-time. Of course, some limitations of these tools led people to think these methods slow down their daily work instead of improving it.

**Keywords:** Industry 5.0, Control Tower System, SAAL Supply Chain, Chaos

## Introduction

Iran's construction industry performs less than other industries, such as automobile manufacturing. The indicators showing this issue are low productivity, frequent cost increases and delays (Sardroud et al., 2020; Srivastava et al., 2022). Despite the development of new technology approaches, such as Building Information Modelling (BIM), the game-changing potential was possible. However, the influx of economic and social crises and the wave of migration of efficient human resources caused it to be lost. The BIM approach was focused on developing technological solutions, for example, to solve

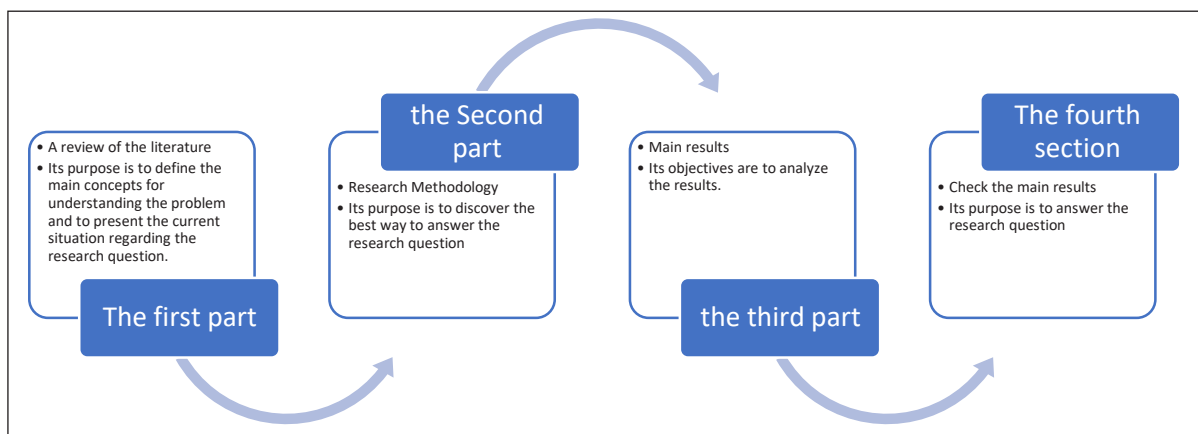
critical issues such as interoperability, improving the dynamics of cooperation, integrating the supply chain and eliminating waste (Khanzadi et al., 2020; Pan & Zhang, 2023).

However, the current conditions of Iran (on the one hand, the continuous increase in prices, lack of materials, efficient workforce, the entry of unqualified people as leading builders, the rejection of the civil engineering community and other cases), as well as a limited number of research studies on the use of BIM tools with the aid of management approaches LEAN and AGILE, it is possible to check and recognise (Hatami & Rashidi, 2023; Khoshfetrat et al., 2022; Moballeghi et al., 2023).

Therefore, adopting solutions from or with new tools or a new look at existing tools.

In this system, an attempt is made to use advanced technologies to help people work better and faster (Maddikunta et al., 2022). This topic evokes the term Industry 5.0. It is a new and emerging phase of industrialisation that encompasses more than just manufacturing and sees humans working alongside advanced technology of Industry 4.0 to enhance workplace processes (Ahmed et al., 2024). Its objectives are to leverage the creativity of human experts and collaboration with efficient, intelligent machines such as cognitive manufacturing systems (Leng et al., 2023; Zeb et al., 2023) to obtain user-preferred manufacturing solutions and resource-efficient, improved focus on sustainability to create more flexible, adaptive and efficient manufacturing processes (Garrido et al., 2024; Ghobakhloo et al., 2023; Masoomi et al., 2023). The goal here is to define the construction industry 5.0.

In this article, the Control Tower System (CTS) tool (which is a kind of integration of BIM tools, business intelligence, the Internet of Things(IoT), blockchain and artificial intelligence) is used with the help of the Last Planner System (LPS) technique (one of the LEAN methods from the Sustainable Antifragile Agile Lean (SAAL) supply chain approach). First, it should be checked that these two tools are complementary and what specific methodology and essential tools each needs for implementation. For this reason, the results of a research project in a typical contracting company that decides to implement CTS with the help of the LPS technique are presented. This article aims to implement CTS successfully with the help of the LPS technique; for this purpose, the main challenges to be overcome were examined. Also, to provide a very first discussion of Construction Industry 5.0, in this paper, we aim to provide an implementation-based tutorial based on potential applications and supporting technologies of Industry 5.0. The article includes four main sections (Fig. 1).



**Fig. 1: Sections of the Article**

## Related Actions

### Definitions and Main Concepts

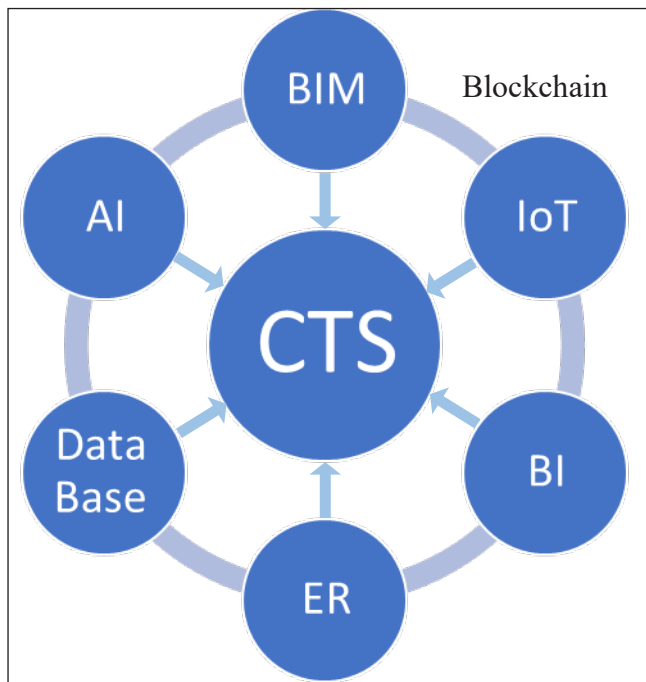
The success and perceived benefits of using Agile, Lean, Sustainable and Antifragile principles in other industries also led to using these principles in the construction industry. According to Sadeghi et al. (2022), the SAAL supply chain studies the construction system by minimising the waste of materials, time and resources, creating maximum added value and taking advantage of the crisis while maintaining sustainability (Sadeghi et al.,

2023; Sadeghi et al., 2022). Among the various LEAN management methods, which are also in the SAAL supply chain, LPS is one of the most popular manufacturing planning and control methods (Olivieri et al., 2019).

The LPS addresses potential hurdles before slowing the flow (Olivieri et al., 2019). Overall, The LPS positively impacts construction projects by reducing rework, delays and uncertainty; increasing collaboration; and improving the final product (Ballard & Tommelein, 2021). Ballard and Howell state that with the help of the LPS process, a procedure for creating a master schedule, a reverse phase schedule, a look-ahead schedule and a weekly

work schedule can be established before taking necessary preventive actions, especially at moments vital with the help of checklists and predetermined responsibilities (Karaz & Teixeira, 2023; Scala et al., 2023).

CTS in the construction industry is a system that includes BIM as “a multi-dimensional, multi-disciplinary, object-oriented model of a built facility to improve and document its design and simulate various aspects of its construction or performance” Business intelligence (BI) to analyse events and examine predetermined scenarios, IoT was created for just-in-time control of on-going events, Extended Reality (ER) in order to simulate and help the people involved to know and check what happened and what may happen, Artificial Intelligence (AI) to analyse the scenario according to the data, Blockchain for data security and data transfers, money and contracts and finally a database to store all the data (Sadeghi, Sadeghi, et al., 2023b) (Fig. 2).



**Fig. 2: Control Tower System Model in the Construction Industry (Sadeghi et al., 2023b)**

Therefore, it can be concluded from Fig. 2 that CTS is a combined process that creates an intense control centre that, in addition to analysing what is happening, allows predicting the future and providing solutions. CTS focus on developing, using and transferring digital information models of a construction project to improve

its design, construction and operation. This system is necessary to implement construction projects under chaotic/anarchic conditions, such as in Iran, and its establishment has advantages and challenges (Sadeghi, Sadeghi, et al., 2023b). In implementing construction projects under chaotic conditions, this comprehensive view is increasingly needed for complete control (Bennett et al., 2023; Gerrits et al., 2022). For many stakeholders, realising the control tower has become a requirement for the project’s timely completion. The effectiveness of this system has been proven through several projects (Rustenburg, 2016).

This system creates a comprehensive view of the project by receiving information. Additional information can be added to multi-dimensional models to analyse and achieve simulation goals. For this issue, along with 3D models, 4D models are created to schedule and simulate the construction process over time. 5D models are prepared for cost management purposes. Similarly, models for security and sustainability, then models for the simultaneous analysis of this information and the implementation of different scenarios, are created according to the identified risks and their continuous and simultaneous effect on the project (Charef et al., 2018; Montiel-Santiago et al., 2020; Sadeghi et al., 2023a, 2023b).

### The Relationship between CTS and LPS

Dow et al. (2016) investigated opportunities for advanced LEAN manufacturing management using IoT standards. Traditionally, production control on construction sites is challenging. Ad hoc production control methods also reinforce uncertainty. LEAN construction methods such as LPS have partially addressed this problem involving construction teams. However, such systems have relatively long scheduling cycles. New solutions such as VisiLean, KanBIM, etc., also require workers to be able to access and be close to computer devices. They enhanced the communication framework underlying such construction management systems with IoT and related standards to automate various communication functions throughout the construction project lifecycle (Dave et al., 2016).

Hill et al. (2017) researched the control and tracking of LEAN production using digital methods. Their scope of work focuses on closing the feedback loop of LEAN construction planning, progress tracking and condition

control, using 4D information from BIM and IoT to report real-time progress. According to them, the visual dimension of BIM can align all available information, so “works are easily controlled, and facility management is improved.” Therefore, it becomes possible to implement an LPS planning approach to plan daily activities. Of course, they also identified some limitations and obstacles: initial cost, technical know-how, and the fact that implementing BIM is time-consuming (Von Heyl & Teizer, 2017).

Dalasega et al. (2018) analysed interactions between real-time IT planning and monitoring approaches and Lean construction. They realised that this integration offered a powerful “real-time” approach to planning and monitoring in construction and the related IT framework, which can improve construction processes beyond the degree that might be improved using either of these paradigms independently (Dallasega et al., 2018).

Ballard et al. (2021) suggested how online systems and LPS relate to the design workflow. They stated that project management functions include human resource management, project financing, project contracts and technology integration, apart from project planning and control. Their research, based on several construction projects, showed that such communication can improve workflow in construction projects by reducing waste. Indeed, to be entirely successful, technology adoption must be accompanied by LEAN management approaches such as LPS for control (Ballard & Tommelein, 2021).

Sadeghi et al. have researched the tower control approach for SAAL’s supply chain strategy in Iran’s construction industry. In Iran’s anarchic construction industry, SAAL supply chain strategy could be an antifragile and value-creating approach. As a controlling unit based on data, the control tower is the core of this supply chain. They said this system could guide the organisation’s managers to identify the best strategies in response to requirements, guidelines and changing opinions of the stakeholders and external global conditions (Sadeghi et al., 2023b).

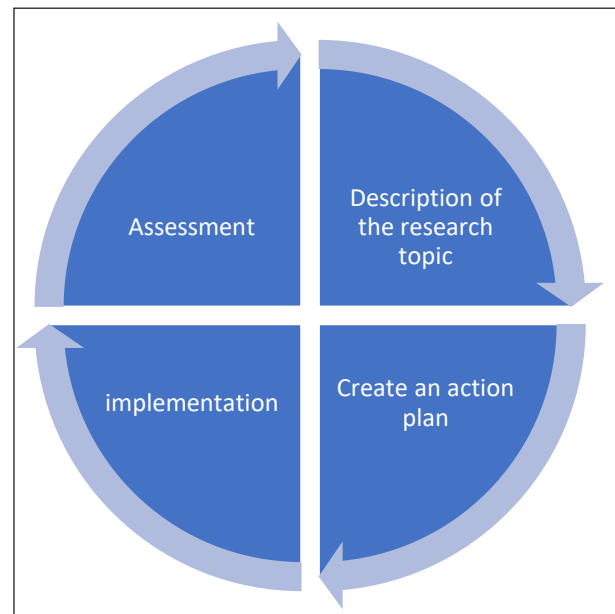
Application software in this field aims to combine the principles and tools of CTS and SAAL approaches using mobile technologies such as mobile phones and PCs on the one hand. Among the essential software, we can mention Trello, ToDo, REVIT, BIM 360 Plan, Power BI, MS Project Primavera and other software and apps

that can be provided based on these platforms (Aithal & Aithal, 2023; Pondel & Pondel, 2017). In this way, a screen is provided for production planning and control, detailed analysis of constraints and allocation of activities and resources to tasks and sending messages and files to create a master schedule with the participation of the entire construction team. Of course, it also provides visualisation of the 3D model. More research needs to be done on control tower evaluation, especially from the perspective of experts (Mikhaylov, 2021; Muttaqin et al., 2020; Nogués & Valladares, 2017; Teizer et al., 2020).

## Research Approach

### Action Research

Action research is a research method that requires the contact of truth and reality. This approach is used to identify needs or problems before developing strategies to achieve change goals in response to problems (Somekh, 2005). Action research has four main stages (Fig. 3):



**Fig. 3: The Four Main Stages of Action Research**

An analysis of the existing processes the investigated company uses highlights gaps to be covered by implementing a new technological tool resulting from the integration of CTS and LPS. In order to understand the context and needs, analysis of planning methods and construction operations, as well as interviews with the

people involved (project manager, supervisor, planner and assistant project manager), were among the basic

requirements. Based on the results obtained from the initial step, an action plan was obtained. The action plan created as part of this research includes five steps (Fig. 4):

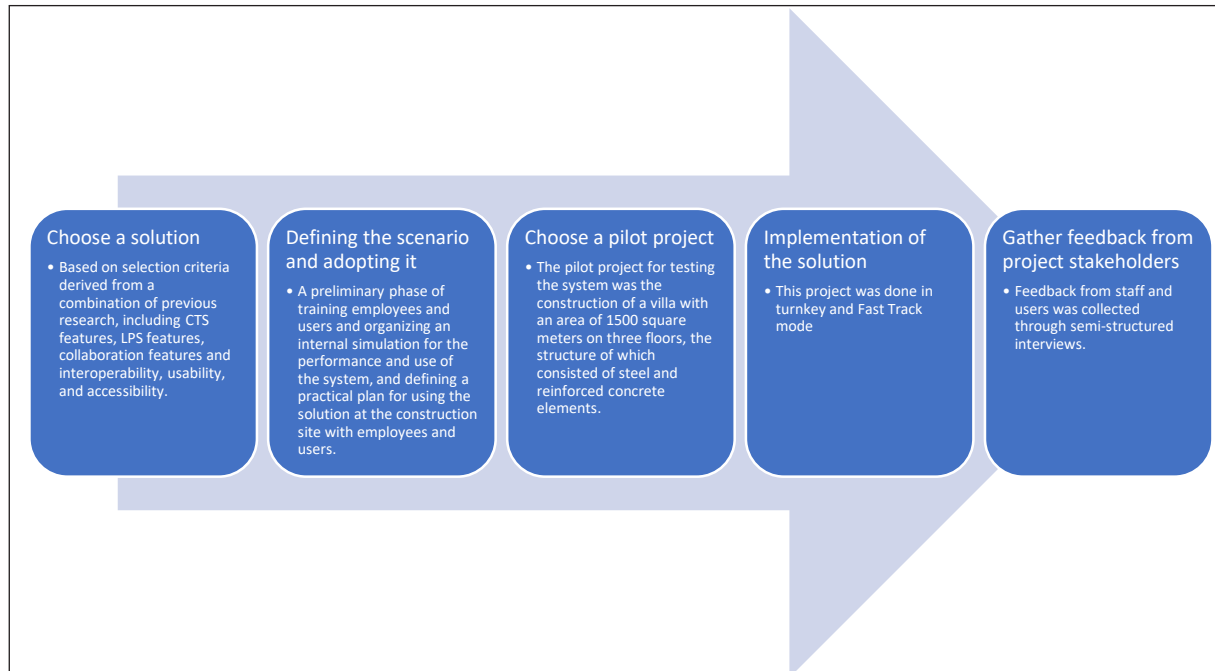


Fig. 4: Created Action Plan

### Statistical Population

statistical population are given in Table 1.

Table 1: Characteristics of the Statistical Population

Gender	Number	Position	Number	Education	Number	Age	Number
Man	159	Executive managers	45	BC	126	30-35	99
		Technicians	87	MC	30	36-40	24
		Supplier and contractor managers	27	Doctorate	3	41-45	36

### Result

#### Summary of Obstacles and Problems

The research results showed that the construction company under research, the builder of the villa project, needs help with problems related to the limitations of traditional planning and production control methods. Their current

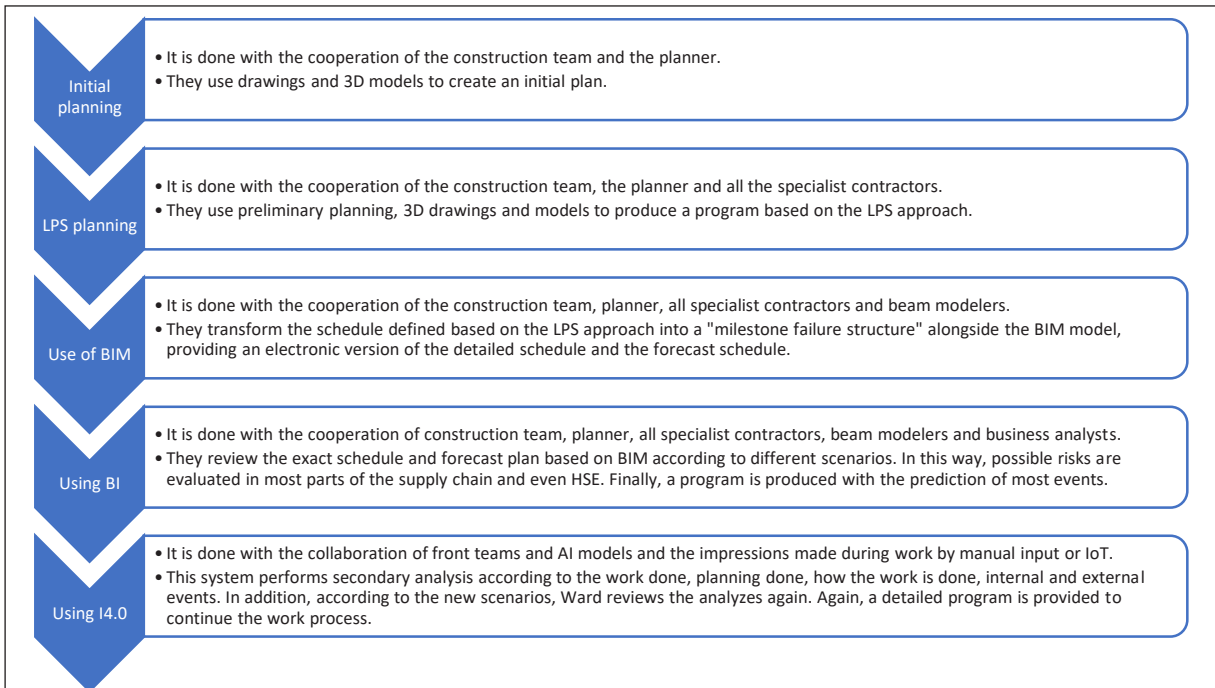
The statistical population of this research includes 53 construction managers and construction teams engaged in this project. The characteristics of the

planning method is push planning, which is a traditional method. This method has problems such as delays in work delivery, waste and reduced productivity. In general, their main schedule is designed only by specialist contractors with little involvement from the involved parties. Company professionals have yet to popularise the use of BIM. Information is shared through an email platform and a shared database, and all documents are accessible through this platform. During the outbreak of the COVID-19 virus and job restrictions, access to documents was more limited because most documents were only available when

they were present in the company. Poor coordination and communication with suppliers and contractors at every stage causes work interruptions or rework.

## Choose New Tools

order to create a sustainable environment for the successful implementation of the system in construction projects. In this logic, the planning process is divided into five stages (Fig. 5):



**Fig. 5: Steps of LSP-Assisted CTS Implementation Planning Process**

According to Fig. 5, the system now provides the "Weekly Work Schedule" and "Daily Work Schedule/Coordination." One of the tasks of the construction team is to ensure that all contractors have access to the system according to their access level in order to be able to plan the tasks they are committed to. In the case of manufacturing control, an additional workflow is also proposed. All contractors must perform a 'Remove Constraints' constraint analysis before commencing tasks, giving them the go-ahead to execute. With the help of this system, the weekly Percent Plan Complete (PPC) is calculated and announced to each contractor. With the help of the control tower system, the construction team can be informed of the progress of each contractor's work and ensure the work's conformity or by physical inspection on site. In addition, each contractor's PPC can be used to check the validity of contractors' payment requests. The project control manager's access also allows him to monitor the

The need for new tools such as CTS based on the SAAL supply chain with the help of the LPS method stems from the company's desire to improve manufacturing operations' planning, control and continuity. Nevertheless, such a system is not only limited to software tools but also requires the updating of current processes and culture in

progress of the contractors' work and be informed of the risks and wastes on the site. All project stakeholders will be notified of changes using an instant notification system. All the main stakeholders, the control manager and the management team are informed about the project status as JIT. Checking and approving contractors' payment requests becomes easy. Checking and confirming the supply of project requirements before the crisis occurs becomes easier. Quality control and confirmation of the continuation of the process are fast. In this case study, only implementation issues were investigated.

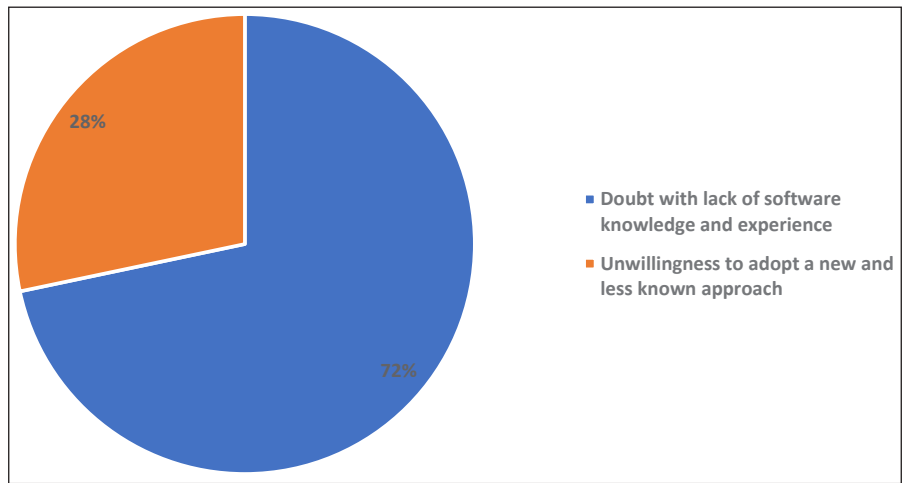
## The Main Challenges

In this study, one of the main challenges was the construction team's resistance against senior management's demands. Due to the issues, the senior management felt the need for innovation, so they supported the implementation of the system. This system could help optimise the planning process and

increase productivity, reducing waste and other new things. Among these are investigating the reasons for the occurrence of risks for workers and reducing safety risks, investigating the reasons for delays and investigating the ability of PPC report data to facilitate payments.

Nevertheless, the construction team considered adopting this system as an additional limitation. The construction team found it difficult to cooperate with all the contractors. Because all employees are always busy and need help to

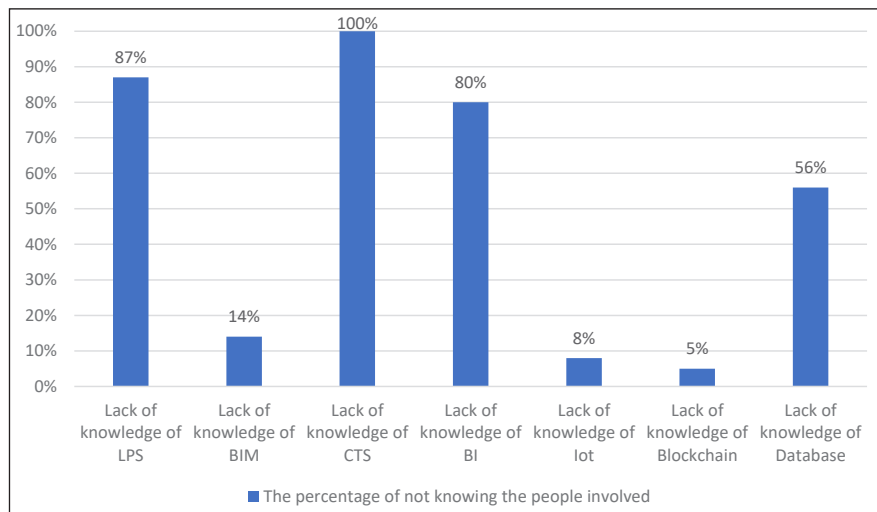
cooperate with contractors, on the other hand, they stated that it is difficult to accept its use because it increases the workload. Therefore, they expressed doubts about the performance and efficiency of this system. On the other hand, they felt that they were constantly under surveillance and had to report for everything. The construction team strongly opposed the implementation of this system. Investigations from interviews with 159 people from the construction team showed that this resistance to change is divided into two general categories (Fig. 6).



**Fig. 6: Resistance to Change**

72% of people in the construction team resist change due to scepticism due to lack of software knowledge and experience, and 28% due to unwillingness to adopt a new and less known approach. Of course, they learn from experience that total reliance on technology is dangerous. Because in 2017, in Iran, the government cut off the whole country’s internet for nearly two months and then

the government started extensive filtering. Meanwhile, Iran’s internet companies have been attacked by hackers many times. According to them, this issue causes people’s work to be disturbed and delayed. Lack of knowledge was also among the issues often mentioned in the interviews. Fig. 7 shows the lack of awareness and knowledge of 53 participants.



**Fig. 7: Diagram of Lack of Knowledge of the Construction Team**

This lack of knowledge is justified by the fact that these concepts are primarily new for many construction companies.

### Solving Challenges

However, the interview results also show encouraging feedback. To successfully adopt CTS, if the construction team is trained, cultured and shown that this approach can simplify planning and create added value, adoption will be facilitated. Because each of them raised need for training during the interviews. It is, therefore, essential to set up an on-going training programme for system users, both for LPS and other systems and methods. According to the opinions of senior management and the construction team, people should be continuously trained to ensure they can use the new systems successfully. In addition, the conditions for using them should be included at the very beginning and even in the contracts. According to his previous experience regarding the implementation of BIM, the construction supervisor emphasises the importance of training workers and states, “CTS, like BIM, is a useful tool, but because people do not know anything about it at first, they hesitate to use it.” Fig. 6 also shows doubts about the performance and efficiency of this new system.

Regarding the concern of complete reliance on systems connected to the internet due to Internet interruption or technical failure, using a full-time person for this purpose for technical assistance and continuous training of software users can simplify the acceptance of the software on the one hand and, on the other hand, motivate and encourage workers to use it effectively. At the same time, using a decentralised integrated system such as blockchain allows the information to be available to everyone at the time of network interruption, and by transferring the file offline; each group can access the stored information again according to the predetermined access level. At the same time, this tool reduces the possibility of hacking.

Another suggestion of the construction team and the senior management is to hire the responsible source of the system to implement the system because, without this person, it will be difficult for the construction team to implement it. Also, not assigning a person to manage documents can make the project manager’s work difficult

when searching for documents. In addition, it is necessary to hire a full-time individual to train users daily and teach them the use of software during the project. According to the interviews and events during the implementation of the system, it is better to use the cooperative approach with users to improve the implementation and practical training of employees. Another influential factor is creating a game mode to use software to motivate and psychologically empower the workers. In a way, they had a reward and punishment system that developed their cooperation without them resisting the current approach. Upgrading the system after the employees expressed the problem was another factor that caused them to cooperate; the result was the automation of processes in some parts to prevent errors in repetitive processes.

This collaboration and co-creation, in line with the use of creative human power and intelligent technologies, in addition to providing the basis for the development of the construction industry 5.0, provides the possibility to consider all aspects of flexibility, resilience and agility at the same time as reducing waste and pollutants and increasing added value and continuous improvement. It primarily focuses on a symbiosis between humans and machines to enhance people’s abilities and improve working conditions. In addition, it emphasises sustainability and cognitive manufacturing systems to create more antifragile manufacturing processes.

### Discussion

According to the results of section 4, it can be stated:

### Contribution to Theory

The problem that most people mentioned is the lack of awareness and knowledge. At the same time, in an atmosphere of chaos, the employees’ decisions are accompanied by doubts and humiliation because people are unfamiliar with this environment. Therefore, it is recommended that employees be trained in different ways. At the same time, people will gradually be exposed to parts of these new technologies and provided with the conditions to use them. In this way, while the employees have been trained and become familiar with the small parts of that tool and have a pleasant experience using it, they will now be ready to accept and use the technology

altogether. In addition, this method allows for the development of these tools according to the needs and ways employees are employed. This method can also encourage employees to participate in developing and improving the desired technology (co-creative).

### Implications for Managers

Using Industry 4.0 technology with a human-centred approach leads to the creation of Industry 5.0. As humans make mistakes, so do computers. Full reliance on both sides can create more crises. However, their integration can lead to good results. Because actual data is scarce in a chaotic environment, it is vital to use tools to collect and analyse as much data as possible. These analyses can lead to creative approaches. CTS allows managers to navigate the environment and conditions in the construction industry more accurately. Managers and experts can make better decisions with the information from these tools. Meanwhile, these tools improve their performance with the help of information from the environment and humans and by correcting errors by humans.

Although repetitive and simple tasks will be eliminated in the short term, in the long term, more tasks will be created, and employees' skills will increase. This leads to continuous improvement and sustainable development.

### Limitations of the Study and Future Research Directions

Any new technology has limitations. In this research, the construction team resists change due to scepticism, a lack of software knowledge and experience and an unwillingness to adopt a new and less-known approach. Non-acceptance of changes was one of the other limitations we faced in this project by employees. Some people think these technologies will make them unemployed, while others imagine these methods will slow down their daily work instead of improving it. Of course, the speed of the Internet and the lack of capable human resources to implement this system in Iran are also limitations. In addition, people do not know the chaotic atmosphere and its characteristics well. Of course, during a crisis, many people's concentration and decision-making power decrease due to a lack of familiarity and preparation. Therefore, in conditions of

uncertainty and certainty, employees prefer to use known and familiar methods instead of innovative methods, which also deteriorate the situation.

### Conclusion

The purpose of the research presented in this article is to investigate the main challenges to successfully implementing CTS software with the help of the LSP technique and introduce Industry 5.0 in the construction industry. This issue requires new tools to improve planning, control construction and build culture under Iran's critical conditions. The purpose of Industry 5.0 is to use intelligent men and machines in order to improve working conditions, exploit conditions and sustainable development. However, there was strong resistance to change from the construction team. For example, some limitations of this tool made the construction team believe that this system could become a disruptive factor that slows down their daily work instead of improving the conditions. Of course, it should be noted that during the interview, the participants emphasised the necessity of adequate training before work and the need for new resources that can be present full-time in the continuous training of construction teams. They realised that the primary goal of these systems is to improve people's working conditions, increase their productivity and security and improve social and environmental conditions.

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