

CONSTRUCTION 4.0 IN THE CONCEPT OF THE RAILWAY

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ABSTRACT. The digital and technological innovations that have been developing massively in recent years are often referred to as the 4th Industrial Revolution or Industry 4.0. The construction industry seems to be somewhat on the sidelines. The big topic is BIM (Building Information Modelling), but this is only one component of the contemplated Construction 4.0. Other topics, if not completely neglected, are minimally neglected in the Czech Republic. Yet, and perhaps for this very reason, it is very important to address them.

This article looks at the description of the different elements of the Construction 4.0 concept and their possible application in transport, through the overall digitisation of the railways.

KEYWORDS: Construction 4.0, digitalisation, railway.

1. INTRODUCTION

The construction industry has innovative solutions and visions at its disposal. However, the key problem is that most construction companies do not consider themselves part of the evolutionary process and behave as if digital innovation has no real impact on them. This means that there is not yet a consensus among most construction executives about the reasons for change and therefore they are not adapting to it. The dominant uncertainties are productivity, costs, quality of work, workforce and skills management, and health and safety, which are just some of the opportunities that Construction 4.0 could address. These need to be factored into a longer-term strategy to adapt in a way that will allow society to thrive in the next phase of digital evolution that will change many aspects of society [1]. As these innovative technologies make their way into different phases of the construction project lifecycle, there is growing concern about the future of jobs. While the use of technology, and robotics in particular, has the potential to increase productivity and safety, it should not necessarily reduce overall employment in the construction industry in the long term. It is expected that existing roles will evolve and new roles will emerge (e.g. employees with digital skills will be needed in addition to designers) [2].

Construction 4.0 in the context of this article includes BIM, virtual and augmented reality, 3D printers, advanced building materials, prefabricated and modular construction, Big Data and predictive analytics, 3D scanning and photogrammetry, autonomous vehicles and drones, cloud collaboration (real-time collaboration), the Internet of Things, or wireless monitoring and device connectivity [3].

Construction 4.0 in railways is somewhat confronted with the fact that transport systems are complex in terms of technology and operation, and involve a range of human actors, organisations and technical solutions.

For the operation and management of such complex environments, a viable solution is the use of intelligent computer systems, such as computerised traffic management systems for air traffic coordination or advanced monitoring and diagnostic systems in vehicles. In addition, the means of transport cannot compromise the safety of passengers by applying operational and maintenance activities. In fact, safety is becoming a more difficult objective to achieve using traditional maintenance strategies and computerised solutions are coming into the picture as the only option to deal with complex systems that interact with each other and try to balance the increase in technical complexity together with stable and acceptable reliability indicators [4].

The importance and significance of railway development through the Construction 4.0 concept is evidenced by efforts to apply it abroad. These include:

1.1. SMARTRAIL 4.0: THE SWISS RAILWAY MODERNISATION PROGRAMME

In the next few years, a number of technical production systems that are important for train travel will be replaced due to their age. At the same time, technologies are being developed at an ever-increasing pace, offering rail companies new opportunities to improve efficiency and punctuality [5].

SBB, BLS, Schweizerische Südostbahn AG (SOB), RhB, Transport public fribourgeois (tpf) and the Public Transport Union (PTU) would like to take advantage of this opportunity together. Together, these companies are preparing the railway for the future as part of the smartrail 4.0 industrial programme. This is the first programme that covers the entire railway production, from timetable planning to train control [5].

As a first step, the concept of this overall architecture has been consolidated and refined in the period

up to 2020, and a more detailed roadmap has been drawn up. The smartrail 4.0 programme is divided into five sub-programmes and covers technological development for the next 20 years. The participating groups are modernising the rail system to ensure the robustness of future services, increase the capacity of existing infrastructure, improve the safety of rail workers and stabilise system costs [5].

1.2. THE CONSTRUCTION 4.0 CONCEPT GOES HAND IN HAND WITH INDUSTRY 4.0

Thanks to digitisation, it is possible to use data obtained from traffic, for example, when planning the development of new railway lines. Recent innovation projects announced by European rail operators Deutsche Bahn (DB) and SNCF are a perfect example of how railways are using FRMCS to become a leader in Industry 4.0. DB, one of the world's largest and most important railways, has announced that it will work with railway experts from Nokia on the "Digitale S-Bahn Hamburg" project, which will use 5G-based FRMCS to deploy – as early as 2021 – highly automated trains and shunting operations on its S-Bahn line in Hamburg [6].

2. AIMS

The aim of this article is to describe the possibilities in terms of Construction 4.0 in the planning and implementation of railways.

Therefore, Building 4.0, in the concept of this paper, has the task of preparing the infrastructure to be ready for operation and maintenance.

3. METHODS

The article mentions the possible use of Construction 4.0 in the railway concept. The research methodology consists in searching the Scopus open access database for relevant articles with innovative solutions and visions. Furthermore, solutions that have been used in the recent past or are yet to be planned to be used in the future are also presented.

4. RESULTS AND DISCUSSION

4.1. FRMCS COMMUNICATION STANDARD

The latest standard for rail communications is moving from the widely adopted GSM-R to the FRMCS (Future Railway Mobile Communications System) standard, with 5G as a key enabling technology. FRMCS sets the stage for total connectivity and seamless end-to-end operations with smarter automation and the ability to leverage new Internet of Things technologies for increased productivity and reliability breakthroughs. Once FRMCS is in place, railways can deliver – in the near future – key improvements that will increase operational speed and deliver a superior ride and travel experience for passengers and goods [6].

4.2. HUMAN FACTOR

The human factor in innovation and development is in many cases one of the slowers of Construction 4.0 transition and application. The natural human reaction to change is fear, rejection and even negativity. In the process of Industry 4.0 development, it becomes therefore necessary and important to involve employees and students in these processes in an early and important way. Their involvement can significantly accelerate the processes, so the development of it should take place in advance. Similarly, the acquisition of technology knowledge or practical experience with machines, software or intelligent programs that they will encounter or actively use in the future to perform their work in the workplace will significantly accelerate and streamline adaptation, leading to increased time efficiency, reduced costs and time-consuming further training of employees [7].

The social (human) factor was identified as the most critical factor that has the greatest impact on the successful implementation of Construction 4.0 in general, but other contributing factors (PESTELS: Political, Economic, Social, Technological, Environmental, Legal and Security factors) suggest that these factors are interrelated and should be addressed simultaneously. The introduction of Industry 4.0 in the construction sector through the principles of Construction 4.0 would put the sector on a par with similar sectors such as manufacturing and automotive, where Industry 4.0 is already widely used [8].

4.3. BIM

Currently, great efforts are being made to achieve a more general application of the BIM methodology in the field of transport infrastructure, beyond specific elements such as tunnels, viaducts and bridges, as evidenced, for example, by the case study of the renewal of a railway line [9]. This highlighted the fact that in the field of transport infrastructure systems, the railway presents specificities and complexities that lend more interest and importance to the implementation of BIM. The highest demands on railway safety (e.g. high-speed train) require more frequent monitoring and maintenance. In addition, the complexity of railway components and systems (infrastructure and vehicles) requires better tools for data analysis and processing. In this sense, BIM will be a useful methodology with huge technical, economic and environmental benefits throughout the life cycle of railway infrastructure. One of the benefits of BIM is the possibility to implement a track inspection system that includes all the usual geometric parameters in order to integrate maintenance planning linked to quality control tests.

4.4. ARTIFICIAL INTELLIGENCE

Possible applications of artificial intelligence in Building 4.0 are:



FIGURE 1. Railways 4.0 with 5G [6].

- design based on artificial intelligence for topology analysis of prefabricated elements – configuration, segmentation and optimization,
- optimisation of supply chain management to reduce costs,
- predicting various potential project risks based on historical and real-time data [10].

4.5. WORKER 4.0

This is a concept that materializes the main principles and behaviors of workers in the Construction 4.0 scenario. Precisely because the productivity of the Worker 4.0 movement is designed to manage and continuously improve processes, the four-stage PDCA management method is appropriate for its implementation. First, an innovation project based on the Worker 4.0 movement's productivity methodologies for craftspeople needs to be planned. The next step is to complete data collection and processing. This means checking process performance to assess the level of mechanization. The last step is to act on productivity in the workplace, implementing control measures and setting up continuous improvement procedures. Such an analysis should be based on the quantitative and qualitative values found in the measurements and the subsequent possibility of improving production indicators [11].

5. CONCLUSION

The article dealt with the use of Construction 4.0 elements that can be used in the construction and downstream operation of railways. Some of these are (fortunately) very close to being used in practice.

During the research it was found that one of the main factors why Industry 4.0 is not as developed in the construction sector as in other sectors is the human factor, whether it is the reluctance to use innovation in practice, the lack of legislation or the need to train employees.

The author believes that it makes sense to continue with the set direction of research in this area, but considers it appropriate to address other parts of the contemplated Construction 4.0 in the railway sector than just BIM. In this vein, the author welcomes the planned establishment of the "Construction 4.0" platform, whose ambition is to bring together major research institutes, especially at technical universities, with progressive construction companies and to offer a space for mutual collaboration. The aim is to introduce new technologies and the use of Industry 4.0 principles into construction and to increase the competitiveness of the Czech Republic in this area on a European scale.

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