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Application of TRIZ in building industry: study of current situation

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Abstract

This article is focused on literature review in the area of TRIZ application in building industry. TRIZ is the Russian acronym for the Theory of Inventive Problem Solving which can be presented as a methodology for problem-solving, ideas-generating and forecasting in innovation, based on logic and data. The theory has been widely used in many fields since early 2000s when innovation became an integral part of the modern World. Despite that, the analysis showed that the number of publications related to application of TRIZ in construction is less than 2% out of all TRIZ-related studies in the SCOPUS database. The paper is organized in the following order: introduction into the topic, the principle of obtaining the dataset for the review, Short description of TRIZ and its possible application in construction, discussion of demand of innovation in building industry and the main body consisting of TRIZ in Development of Construction Techniques and Technologies, TRIZ in Design of New Structures and Construction Materials and TRIZ in Construction Project Management and Value Engineering. The work ends with conclusion, suggestion for future work and acknowledgment. Overall, 28 scientific works regarding application of TRIZ in building industry were discovered and reviewed in this paper. The study reveals that TRIZ usage in construction is still quite limited. The further research will adapt classic TRIZ tools for construction engineering and management and provide a number of specific case studies.

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*Keywords:*TRIZ; building industry; construction; innovation.

1. Introduction

Construction engineering and construction management are professional disciplines within building industry which deal with design, overall planning, construction and management of infrastructures (buildings, bridges, utilities, etc.). To succeed in those aspects construction specialists have to always find new solutions and ideas, solve technical and technological issues which may appear in every single project`s stage during both design and construction. Thanks to bright innovative ideas and solutions, which enable the scientists and engineers to evolve construction materials, technologies, design techniques, etc., the World nowadays has such truly astonishing structures as the Dubai's Burj Khalifa (the tallest man-made structure in the world, standing at 829,8 m), the Sidu River Bridge in China (the bridge with the biggest drop distance from the bridge deck to the ground level which is nearly 500m high and crosses a mountain belt), the incredible Milau Viaduct in France (the world's tallest bridge with one mast reaching 343 meters above the base of the structure), the China's Jinping-I Dam (the tallest dam 305m high), the Capital Gate tower (the World's furthest leaning skyscraper in Abu Dhabi that was built to lean 18°) and a few others. Moreover, there are quite simple structures differing by the way they were built. For instance, a Chinese construction company used a Modular method and became the world's fastest builder after erecting a 57-storey skyscraper in 19 working days in central China [1]. The method enables the builders to assemble the prefabricated blocks (modules) instead of building brick by brick.

In the modern professional world engineers and managers must have a universal intellectual set of tools that would enable them to find the right ideas in a well-structured methodological way avoiding consideration of knowingly false solutions leading to waste of time, missed deadlines, planned budgets, etc. Since the risk of failure in construction is higher than in many other industries [2] it is not acceptable to use trial-and-error approach (especially for large-scale projects) to find ideas and solutions for the development and improvement of design procedures, structures and

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construction techniques. At the same time, there is the Theory of inventive problems solving (TRIZ) which includes a practical methodology, tool sets, a knowledge base, and model-based technology for generating new ideas and solutions for problem solving [3]-[5]. According to ETRIA (the European TRIZ association) Worldwide survey performed in 2009 [6], only 3,5% of construction professionals are devoted to the TRIZ, which means that TRIZ remains marginal in the building industry. This paper presents scientific indexed literature review to a) identify existing innovative approaches based on TRIZ tools which find their application in design and construction and help solving ongoing issues, b) justify relevance of further study of TRIZ application in building industry and, finally, develop a set of key objectives to be later investigated.

2. Creating the dataset

The review is based on papers indexed by SCOPUS mostly database. In order to create the set of articles to be reviewed, two searches were performed: (1) the search query “TRIZ” and “Construction” in Title or Abstract or Keywords and (2) “TRIZ” and “Building” in Title or Abstract or Keywords. The terms “Construction” and “Building” were selected as they are most commonly used in the studied field while “TRIZ” as generally accepted abbreviation for the Theory of Inventive Problem Solving. The former case resulted in 83 papers while the latter in 57 ones. However, reading the papers filtered out the irrelevant texts that reduced the quantity to only 18 and 6 industry-related articles respectively with 2 of them being in both lists. Thus, the dataset consists of 22 articles selected from the SCOPUS database. It is just 2% of the 1389 articles retrieved by “TRIZ” in Title or Abstract or Keywords search. Quick analysis shows that 9 of articles are cited more than once. Most of the works originated from the PRC during the last decade. As the amount of retrieved papers is small, the Google finder was used to extend the list of reviewed papers. The search query “TRIZ” and “Construction” and “Building” forwarded us to such sources as ScienceDirect, Elsevier and Springer where 6 more industry-related papers were obtained. All bibliographic information is given as it was seen in May 2015. Thus, 28 works regarding application of TRIZ in construction were discovered and reviewed in this paper, some of which are available in abstracts only. The review showed that those articles are mostly dedicated to:

-Development of Construction Techniques and Technologies

-Design of New Structures and Construction Materials

-Construction Project Management and Value Engineering

3. Demand of Innovation in Construction

First, we need to comment the demand for innovation in construction in general. According to [8] innovation can be defined as “the successful exploitation of new ideas. However, ongoing research [2], [9]–[12] and statistical data [6], [8] show that construction lags behind many other industrial sectors (such as IT, computers, software, automotive industry, electronics, mechanical engineering, etc.) in terms of efficiency and productivity due to mostly lack of realizations of new ideas.

For instance, U. Kulatunga et al. demonstrate [2] that construction is behind other industrial sectors due to, in particular, lack of innovations. At the same time modern construction companies are keen on innovations to be competitive on the market, which is why engineers and managers innovate when technology can be modified easily. On the other hand, construction industry is also known for its conservatism and professionals tend to use an accepted industry practice and norms in fulfilling client’s need.

The study [11] by S. Asad et al. also shows the importance of innovations for construction organizations. The authors even claim that construction innovations can become a fourth dimension in the future along with the traditional dimensions of cost, quality and time. Only in that case such organizations would be able to take advantage of changes in market economy. The study [13] additionally explains that successful building products must be innovative to become competitive on the market in terms of cost, time and performance efficiency. Besides, the survey performed by the Chartered Institute of Building (UK) [8] discovered that 100% of respondents felt that innovation is important for the future of construction.

To sum up, there is plenty of research, surveys and literature regarding innovation in construction and almost all of them state that innovations are vital in construction sector but the question is how to become innovative. Z. Ding and J. Ma [14] describe that using TRIZ can accelerate technical innovations in construction process. On the other hand, the report [6] shows the statistical data related to distribution of TRIZ use in industrial sectors which demonstrate that TRIZ is not widely used in civil engineering and building industry. The other work [15] by D. M. Conall and Ó. Catháin explains again that construction specialists in most cases do not use systematic or formal design methods and this situation leads to a number of drawbacks (for instance, it takes a long time to find a solution; waiting for inspiration; designers cannot proceed in a logical manner, etc.). To avoid such minuses a systematic innovation approach was suggested, which came out of TRIZ. The approach is based on five principles called "pillars" which are function, contradiction, resources, ideality and interfaces.

Furthermore, Y. Mohamed and S. AbouRizk [16]–[18] noticed that there is lack of structured theory for managing innovation improvement in the construction industry. Innovation is an integral part of improvement of construction techniques but, however, most approaches are based on the trial-and-error method. The studies present a few number of cases to show results of TRIZ application in tunnel construction. All case studies were taken from real life situations and it was well proven that TRIZ tools help to achieve innovative conceptual solution in a methodological way avoiding consideration of irrelevant results.