International Business & Economics Studies
ISSN 2640-9852 (Print) ISSN 2640-9860 (Online)
Vol. 6, No. 2, 2024
www.scholink.org/ojs/index.php/ibes

Original Paper

Review of Research on Uncertain Repetitive Project Scheduling

Zhou Lin[1&2*], Yifei Li[1] & Wang Hao[2]

[1] School of Economics and Management, North China Electric Power University, Beijing, China

[2] School Management, Gui Zhou University, Gui Zhou, China

[*] PhD students: lzhou3@gzu.edu.cn

Received: February 11, 2024 Accepted: Apri 11, 2024 Online Published: April 28, 2024

doi:10.22158/ibes.v6n2p274 URL: http://dx.doi.org/10.22158/ibes.v6n2p274

Abstract

With the continuous development of project management practice, the project often suffers from disturbance events in the actual execution activity, which leads to project delay and great economic losses.Uncertainty project scheduling studies have also received attention.Repetitive project is a type of project with its own characteristics in which the construction site can be divided into several independent units and all activities are repetitive on multiple units, such as high-rise buildings, highways, and pipeline works. The characteristics of repetitive project controlling paths and controlling activities have their own advantages in responding to uncertain events. This paper takes repetitive project scheduling as the object to sort out its uncertain scheduling research. Firstly, the uncertain research based on probability random theory, fuzzy set theory and robustness theory is summarized, and then the research on different scheduling strategies such as interruptions soft logic and multi-mode in repetitive project scheduling is further summarized. Finally, the current research status of uncertain reactive scheduling is summarized,and further research directions are pointed out.

Keywords

repetitive project, project scheduling, scheduling strategy

As the construction scale becomes larger and larger and the construction environment becomes more and more complex, the repetitive project is very vulnerable to the impact of extreme weather environment, adverse geological conditions, policy changes and other interference events, resulting in project delay and significant economic losses. Kamrul Ahsan (2010) investigated 100 infrastructure projects sponsored by Asian Development Bank. Due to the interference of uncertain factors such as natural disasters and shortage of funds, 86% of the projects experienced construction delays of varying degrees, with an average delay of two years and an average cost overrun of 73 million US dollars. In China, most of the repetitive projects are infrastructure projects, so how to deal with the impact of uncertain events is a practical problem that needs to be solved urgently.

1. Research on Scheduling of Uncertain Repetitive projects

Research on repetitive project scheduling under uncertain environment can be divided into three categories: random project scheduling, fuzzy project scheduling and robust project scheduling. Among them, stochastic project scheduling and fuzzy project scheduling focus on using stochastic theory and fuzzy theory to model and describe uncertain factors, while robust project scheduling refers to using the concept of robustness in controlling theory to reflect the ability of the system to withstand the influence of uncertain factors, and fully mining the internal structure characteristics of the project to develop a schedule plan with strong anti-interference ability and flexible coping strategies. Although a lot of progress has been made in the research of repetitive project scheduling under the deterministic environment, the research of taking the uncertainty factor into the repetitive project scheduling is still very limited. The existing researches are mainly carried out from the following three aspects:

1.1 Based on Probabilistic Stochastic Theory

Yang and Chang (2005) argued that repetitive projects usually have a long construction cycle, and it is difficult for their resource supply to remain stable for a long time. Aiming at this problem, an opportunity-constrained programming model constrained by probabilistic resource supply conditions was established, and the optimal scheduling scheme was obtained by transforming the stochastic programming model into a standard linear programming model. Tokdemir et al. (2018) designed a stochastic risk assessment method that included duration and resource uncertainty, and used Monte Carlo simulation to test the effectiveness of the method. The research results showed that the output of this method could enable decision makers to estimate the delay risk under various circumstances. Abbas et al. (2020) considered the uncertainty of execution rate, combined resource-driven technology with Monte Carlo stochastic simulation technology, and obtained the optimal scheduling task force allocation scheme by using genetic algorithm. The contribution of this research is to establish a new multi-objective stochastic scheduling optimization model for sequential and non-sequential repeat constructions.

1.2 Based on Fuzzy Set Theory

Maravas et al. (2011) believed that the differences among activity units, the performance of the task force, the allocation and sharing of resources in the activity and other factors would lead to the difference in the expected execution rate of the activity. Fuzzy set theory was introduced into RSM to construct the uncertainty of the execution rate of repetitive projects and solve the uncertainty problem of repetitive projects in practice. Moselhi et al. (2016) considered the uncertainty of rush cost, that is, the cost required for each rush operation is unknown. Based on the fuzzy set theory, they established the uncertain relationship between rush operation and rush cost, and introduced the risk identification method based on the micro-risk decomposition structure and the risk responsibility matrix according to the principle of cost priority and contractors' own preferences. Proposed a rush strategy for repetitive projects under the condition of rush cost uncertainty, and used fuzzy set and fuzzy probability theory to evaluate each project qualitatively and quantitatively. Bakry et al. (2016) used fuzzy set theory to model the time uncertainty in repetitive projects, converted the resulting fuzzy scheduling plan into an executable definite schedule plan through de-fuzzification technology, and further introduced satisfaction index to measure the confidence level of project managers on the risks of different activities, so as to determine the buffer size of activities. Salama et al. (2017) proposed a scheduling method that integrated LSM (Linear Scheduling Method) & CCPM (Critical Chain Project Management) and introduced the concept of resource conflict buffer to protect the schedule plan from the impact of resource fluctuations in view of the uncertainty of activity construction period. On the basis of the above two literatures, Salama and Moselhi (2019) established a multi-objective scheduling optimization model considering the uncertainties of activity schedule, and realized the optimization of project duration, cost and discontinuity at the same time.

1.3 Based on the Robustness Theory

Ja kowski (2020) considered the uncertainty of the operation period and was umpire to improve the completion probability of the schedule plan. Zhang et al. (2020) introduced the robust scheduling theory into repetitive project scheduling, studied the uncertainties of work continuity unique to repetitive projects, and established a resource-robustness trade-off optimization model by taking advantage of the ability of the time difference between the inverse controlling activity and the start-point controlling activity to absorb the uncertainty disturbance. Volk (2017) divides the research on project scheduling under uncertain environment into three categories: stochastic project scheduling, fuzzy project scheduling and robust project scheduling. It is clear that stochastic project scheduling and fuzzy project scheduling focus on using stochastic theory and fuzzy theory to model and describe uncertain factors, while robust project scheduling refers to using the concept of robustness in controlling theory to reflect the ability of the system to withstand the influence of uncertain factors, and fully mining the internal structure characteristics of the project to develop a schedule plan with strong anti-interference ability and flexible coping strategies. Slawomir et al. (2017) also used LSM to speed up construction by working overtime and adding additional resources, and to establish a reactivity linear planning model with minimum cost. Hegazy (2022) uses soft logic and multi-modal approaches to change scheduling plans, developing an algorithm with four optimization modules to fix scheduling plans through soft logic and changing execution modes, aiming to meet project deadlines with minimal cost.

2. Research on Common Scheduling Strategies for Repetitive Projects

2.1 Research on Interruptions Strategy

Li and He (2015) built a multi-modal reactive scheduling optimization model with the goal of minimizing the cost caused by resource discontinuity. Zou X et al. (2019) Altuwaim et al. (2018) developed a multi-objective optimization model to minimize the reduction of project interruptions, interruption time and interruption cost, and considered the possibility of assigning the task force with interruption to other projects. In this way, the hiatus cost will include not only the idle cost of resources, but also the cost of resource movement caused by the allocation of resources to another project. Salamah & Moselhi first studied the impact of discontinuities on schedule under uncertain environment. They used fuzzy set theory to express the execution rate, workload and resource availability of a task force, and proposed a scheduling optimization method for repetitive project time, cost (including interruptions cost) and work interruptions (total interruptions time). Liu, Yuan et al. (2019) studied the interruptions project scheduling problem of a class of tasks with multi-skill resources and time window constraints and established the corresponding integer programming model. Elloumi et al. (2020) studied the pattern change discontinuity in the Multi-Mode Resource-Constrained Project Scheduling Problem (MRCPSP). In fact, during the execution of a project, some unexpected events may occur, causing the schedule to deteriorate or even become unfeasible, and a reactive mathematical model is proposed. The floating-point based robustness metric proposed by Zhang & Dai can measure the ability of scheduling to absorb unpredictable and harmful discontinuity, and propose a method of uncertain scheduling. Roghabadi and Moselh (2020) further proposes a scheduling model that can seek optimal task force composition for repetitive projects. Hegazy et al. (2021), in order to generate a more compact schedule for repetitive projects, relaxed the constraints on work continuity and achieved better results. Chakrabortty et al. (2021) evaluated the performance of their proposed reactive scheduling method based on disturbance events in response to resource discontinuity, and showed that the method generated a higher quality solution for RCPSP in an average time of less than 5 seconds than the most advanced heuristic algorithm. As a continuation of the above research, Wang and He (2023) demonstrate that emergency rescue is highly uncertain and dynamic. They apply the theory and technology of project scheduling under uncertain environment to deal with emergencies under random resource discontinuity through collaboration and cooperation between proactive and reactive scheduling methods. Proactive scheduling and reactive scheduling methods adopt appropriate disposal strategies at any time in response to environmental changes to make rapid and effective emergency responses; Mostafa et al. (2023) improved Dai Guyu et al. (2023) introduce discontinuities into the traditional resource equalization problem for the first Zhiyuan Hu et al. (2023) studied Wang and Zhang (2023) designed a heuristic algorithm for project scheduling problems with preemptive resource constraints that allow activities to be interrupted at any unit time node.

2.2 Research on Soft Logic

Zhang et al. (2013) Huang et al. (2016) Scheduling with variable work sequence is called the soft logic method, and a model considering soft logic is established to solve the DTCTP problem in repetitive construction projects. Wang et al. (2017) introduced the soft logic relation, analyzed the influence of the soft logic relation on the scheduling scheme of repetitive projects from the perspective of maximization of scheduling duration-cost utility for repetitive projects, and built the scheduling time-cost optimization model for repetitive projects. Zou X et al. (2020) developed a flexible repeatable scheduling model by integrating soft logic into time-cost tradeoff. Xin Zou et al. (2021) studied the three-objective tradeoff optimization problem considering the construction period, cost and interruption time of soft logic, and proposed a mixed integer linear model of the problem and its exact algorithm to solve it. ε-constraint Monghasemi et al. (2021) proposed a linear optimization model in LSM that could identify the optimal unit construction sequence to minimize the total project cost and the number of work team interruptions. Hegazy (2022) uses soft logic and multi-modal means to manually change scheduling plans, aiming to meet project deadlines with minimal cost. Zou et al. (2022) discrete time cost trade-off problem for repetitive projects considering soft logic aims to determine the execution mode of each activity, the assignment plan of the work team and the construction sequence among units, minimize the total cost of the project under the conditions of meeting the given deadline, and further improve the solution efficiency. Zhang and Li etstudied the robust project scheduling optimization problem considering soft logic to further improve the ability of project scheduling schemes to cope with the interference of uncertain factors. The above studies all consider soft logic to make the project benchmark schedule under certain conditions, and no studies have been found to consider the task variability of the task force alone. Zhang Lihui's research team continued to optimize the above model in 2016, 2020 and 2021, respectively, by taking into account factors such as resource transfer cost, reducing the number of construction teams, and maximizing work continuity, and proved that the choice of their construction sequence has a greater impact in RSM(Repetitive Scheduling Method). Zou et al. (2023) proposed a soft logic relationship model that comprehensively considered variable construction sequence and allowed multiple construction groups to be constructed at the same time. At the same time, resource transfer was introduced to restrict the selection of logical relationships, and a CSLSPRPRT model was constructed with the goal of balancing the dual objectives of construction period and cost.

2.3 Research on Multi-Mode Scheduling Strategy

Chakrabortty et al. terms of MRCPSP, Mario Gnagi et al. (2019) Reza et al. (2020) Yisong et al. (2021) Fernandes et al. (2021) Peng and Lin (2022) Cao, He, Wang et al. (2022) Li, He, Wang et al. (2022) When an activity has multiple execution modes, the robust value of the satisfactory solution is higher than that of the single mode. Wang and He (2023) Emergency rescue is highly uncertain and dynamic. By applying project scheduling theory and technology under uncertain environment to optimize multi-mode project scheduling for emergency rescue under random resource discontinuity, the research results show that through the collaboration and cooperation of proactive and reactive scheduling methods, The project losses can be reduced to a greater extent through collaboration and cooperation of proactive and reactive scheduling methods. Ramos Alfredo S et al. (2023) Xianghua C (2023) et al.

2.4 Literature Review and Summary

To sum up, the research on uncertain repetitive project scheduling is mainly based on probabilistic random theory, fuzzy theory, robustness theory and other theories, and adopts scheduling strategies such as discontinuity, soft logic and multi-mode to study. Based on the above literature summary, the status quo and trends of related research can be summarized as follows:

At present, there are few studies on reactive scheduling of repetitive projects in the uncertainty research of repetitive projects, and no one has carried out research on reactive scheduling quick repair strategy. For the research on reactive scheduling of general projects, only a few adopt a single multi-mode strategy and activities interruption strategy to adjust the unexecuted activities. Under the condition that the original resources remain unchanged, there are almost no research results on the application of multiple strategies such as soft logic, discontinuity, multi-task force and multi-mode for reactive scheduling optimization.

Robust project scheduling has more potential because of its fundamental strategies to deal with uncertainty disturbance, and has become the latest hot research direction in the field of uncertain project scheduling. Recently, proactive scheduling and reactive scheduling have been combined. From the existing literature, it can be seen that robust scheduling focuses on the treatment strategy of uncertain factors, but ignores the fundamental characteristics of the controlling activity. Compared with fuzzy scheduling and random scheduling, the characteristics of repetitive project controlling activities are highly consistent with the robust scheduling theory, and the combination of the two is likely to open up a new world for the research of repetitive project scheduling under uncertain environment.

In the Interruption and soft logic strategies studies,Previous studies mainly focused on the relationship between the total duration and total cost of repetitive projects caused by resource discontinuity. From the construction and design of single-objective to multi-objective modeling algorithms, optimization problems such as minimizing project duration, balance between cost, work discontinuity and resource continuity were discussed. However, few studies combined with soft logic were found. In the research field of soft logic, scholars mainly focus on the adjustment of the logical sequence of the activity and the optimization of the logical sequence of the unit, and devote themselves to establishing the model of multi-objective problems such as duration and cost, and designing the corresponding algorithm. However, there is no research on the application of soft logic to project scheduling problems in uncertain environments. Therefore, the Interruption and soft logic to reactive scheduling has great research potential.

References

Abbas, H., El-Rayes, K., & Mohamed, A. (2020). Optimizing the scheduling of crew deployments in repetitive construction projects under uncertainty. *Engineering, Construction and Architectural Management*, *27*(10), 3095-3113.

Ahsan, K., & Gunawan, I. (2010). Analysis of cost and schedule performance of international development projects. *International Journal of Project Management*, *28*(1), 68-78. https://doi.org/10.1016/j.ijproman.2009.03.005

Altuwaim, A., & El-Rayes, K. (2018). Minimizing duration and crew work interruptions of repetitive construction projects. *Automation in Construction*, *88*, 59-72. https://doi.org/10.1016/j.autcon.2017.12.024

Bakry, I., Moselhi, O., & Zayed, T. (2016). Optimized scheduling and buffering of repetitive construction projects under uncertainty. *Engineering, Construction and Architectural Management*, *23*(6), 782-800. https://doi.org/10.1108/ECAM-05-2014-0069

Cao, F. F., He, Z. W., & Wang, N. M. (2024). Proactive and reactive project scheduling based on dynamic updating of activity duration information [J/OL]. *Systems Engineering Theory and Practice*, 1-22.

Chakrabortty, R. K,, Rahman, H. F., Haque, K. M. A. et al. (2021). An event-based reactive scheduling approach for the resource constrained project scheduling problem with unreliable resources. *Computers & Industrial Engineering*, *151*, 106981. https://doi.org/10.1016/j.cie.2020.106981

Chakrabortty, R. K., Sarker, R. A, & Essam, D. L. (2016). Multi-mode resource constrained project scheduling under resource disruptions. *Computers and Chemical Engineering*, *88*(may 8), 13-29. https://doi.org/10.1016/j.compchemeng.2016.01.004

Dai, G. Y., & Liao, M. J. (2019). Resource levelling in repetitive construction projects with interruptions: An integrated approach. *Journal of civil engineering and management*, *29*(2), 93-106. https://doi.org/10.3846/jcem.2023.17568

Elloumi, S., & Loukil, T. M. (2020). Fortemps P.Reactive heuristics for disrupted multi-mode resource-constrained project scheduling problem. *Expert Systems with Applications*, *167*, 114132. https://doi.org/10.1016/j.eswa.2020.114132

Fernandes, G. A., & de Souza, S. R. (2021). A matheuristic approach to the multi-mode resource constrained project scheduling problem. *Computers Industrial Engineering*, *162*(2021), 162. https://doi.org/10.1016/j.cie.2021.107592

Gnagi, M., Rihm, T., Zimmermann, A. et al. (2019). Two Continuous-Time Assignment-Based Models for the Multi-Mode Resource-Constrained Project Scheduling. Computers Industrial Engineering, 129346-353. https://doi.org/10.1016/j.cie.2019.01.033

He, Z. W., NING, M. J., & XU, Y. Q. (2016). A review of proactive and reactive project scheduling methods. *Operations Research and Management*, *2016*(25), 278-287.

Hegazy, T. K. E. (2022). Schedule optimization for scattered Repetitive projects. Automation in Construction, *133*(1), 1-13. https://doi.org/10.1016/j.autcon.2021.104042

Hegazy, T., Mostafa, K., & Ojulari, S. (2021). Tetris-inspired approach for generating tightly-packed repetitive schedules. Automation in Construction, *124*(2021), 103601. https://doi.org/10.1016/j.autcon.2021.103601

Hu, Z., Wang, F., & Tang, Y. (2023). Scenario-oriented repetitive project scheduling optimization. *Computer-Aided Civil and Infrastructure Engineering*, *38*(10), 1239-1273. https://doi.org/10.1111/mice.12917

Huang, Y. X., Zou, X., & Zhang, L. H. (2016). Genetic Algorithm-Based Method for the Deadline Problem in Repetitive Construction Projects Considering Soft Logic. *Journal of Management in Engineering*, *32*(4), 04016002. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000426

Ja kowski, P., Biruk, S., & Krzemi, L. ski M. (2020). Planning repetitive construction activity to improve robustness of schedules in risk environment. *Archives of Civil Engineering*, *66*(3), 643-657. https://doi.org/10.24425/ace.2020.134418

Li, J. Y., & He, Z. W. (2015). Reactive multi-mode project scheduling optimization based on random resource discontinuity. *Operations Research and Management*, *24*(06), 44-50.

Li, Y., He, Z. W., Wang, N. M. et al. (2022). Robust optimization of multi-model projects with fuzzy duration. Industrial Engineering and Management, *27*(04), 39-49.

Liu, Z. Y., Yuan, H. T., Zhou, C., Bi, Y., & Hu, S. F. (2019). Branch-and-bound algorithm for discontinuous project scheduling under multi-skill resource time window constraints. *Systems Engineering Theory & Practice*, *39*(1), 184-199.

Maravas, A., & Pantouvakis, J. P. (2011). Fuzzy Repetitive Scheduling Method for Projects with Repeating Activities. *Journal of Construction Engineering & Management*, *137*(7), 561-564. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000319

Monghasemi, S., & Abdallah, M. (2021). Linear Optimization Model to Minimize Total Cost of Repetitive Construction Projects and Identify Order of Units. *Journal of Management in Engineering*, *37*(4). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000936

Moselhi, O., Bakry I., & Alshibani, A. (2016). Accelerating repetitive construction projects: with uncertainty and contractors judgment. *Canadian Journal of Civil Engineering*, *43*(11), 949-957. https://doi.org/10.1139/cjce-2014-0347

Mostafa, K., Ojulari, S., & Hegazy, T. (n.d.). Enhanced repetitive scheduling formulation for meeting deadlines and resource constraints in linear and scattered projects. *Canadian Journal of Civil Engineering*, *50*(3), 172-183. https://doi.org/10.1139/cjce-2022-0029

Ramos, A. S. et al. (2023). A Formulation for the Stochastic Multi-Mode Resource-Constrained Project Scheduling Problem Solved with a Multi - Start Iterated Local Search Metaheuristic. *Mathematics*, *11*(2), (2023), 337-337. https://doi.org/10.3390/math11020337

Reza, N. L., & Hamed, D. A. (2020). Multi-mode resource constrained project scheduling problem along with contractor selection. *INFOR Information Systems and Operational Research*, *59.2*(2020), 1-20. https://doi.org/10.1080/03155986.2020.1803720

Roghabadi, M. A., & Moselhi, O. (2012). Optimized crew selection for scheduling of repetitive projects. Engineering Construction & Architectural Management, *28*(6), 1517-1540. https://doi.org/10.1108/ECAM-10-2019-0590

Salama, M. T., Salah, A., & Moselhi, O. (2017). Integration of Linear Scheduling Method and the Critical Chain Project. *Canadian Journal of Civil Engineering*, *45*(3), 30-40. https://doi.org/10.1139/cjce-2017-0020

Salama, T., & Moselhi, O. (2019). Multi-objective optimization for repetitive scheduling under uncertainty. *Engineering Construction and Architectural Management*, *26*(7), 1294-1320. https://doi.org/10.1108/ECAM-05-2018-0217

Slawomir, B., Piotr, J., & Agata, C. (2017). Updating Linear Schedules with Lowest Cost: A Linear Programming Model. *IOP Conference Series: Materials Science and Engineering*, *245*(7). https://doi.org/10.1088/1757-899X/245/7/072011

Tokdemir, O. B., Erol, H., & Dikem, I. (2018). Delay Risk Assessment of Repetitive Construction Projects Using Line-of-Balance Scheduling and Monte Carlo Simulation. *Journal of Construction Engineering and Management*, *2*(145), 4018132. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001595

Tom, P., Christian, A., & Romain, G. (2024). Robust decision trees for the multi-mode project cheduling problem with a resource investment objective and uncertain activity duration. *European Journal of Operational Research*, *312*(2), 525-540. https://doi.org/10.1016/j.ejor.2023.07.035

Volk, R. (2017). *Proactive-reactiverobust scheduling and capacity planning of deconstruction projects under uncertainty*. KIT Scientific Publishing.

Wang, M., & Zhang, Z. X. (2023). Multi-preemptive project scheduling optimization based on time window delay. *Operations Research and Management*, *32*(6), 46-52.

Wang, W. X., Ge, X. L., Wang, X., & Ni, L. (2017). Research on cost optimization of repetitive project scheduling based on soft logic Relationship. *Journal of Management Engineering*, *31*(1), 201-207.

Wang, Y. T., & He, Z. W. (2019). Robust multi-model project scheduling optimization for emergency rescue under random resource discontinuity. Operations Research and Management, *32*(03), 70-77.

Wu, L. P., & Lin, J. L. (2022). An Improved reactive scheduling Problem for multi-model projects. *Operations Research and Management*, *31*(07), 28-34.

Xianghua, C., Shuxiang, L., Fei, G. et al. (2023). A data-driven meta-learning recommendation model for multi-mode resource constrained project scheduling. Computers and Operations Research, *157*(09), 1-15. https://doi.org/10.1016/j.cor.2023.106290

Xin, Z., Wu, G. C., & Zhang, Q. (2021). Work continuity constraints in repetitive project scheduling considering soft logic. *Engineering, Construction and Architectural Management*, *28*(6), 1713-1738. https://doi.org/10.1108/ECAM-11-2019-0595

Yang, T., & Chang, C. Y. (2005). Stochastic resource-constrained scheduling for repetitive construction projects with uncertain supply of resources and funding. *International Journal of Project Management*, *23*(7), 546-553. https://doi.org/10.1016/j.ijproman.2005.03.003

Yisong, Y., Sudong, Y., Lin, L. et al. (2021). Multi-objective multi-mode resource-constrained project scheduling with fuzzy activity durations in prefabricated building construction. *Computers Industrial Engineering*, 158. https://doi.org/10.1016/j.cie.2021.107316

Zhang, L. H., Dai, G. Y., Zou, X.. et al. (2020). Robustness-based multi-objective optimization for repetitive projects under work continuity uncertainty. *Engineering Construction and Architectural Management*, *27*(10), 3095-3113. https://doi.org/10.1108/ECAM-08-2019-0458

Zhang, L. H., Li, Y. F., Zou, X. et al. (2023). Robust project scheduling optimization considering soft logic. *Operations Research and Management*, *32*(09), 28-35.

Zhang, L. H., Zou, X., & Qi, J. X. (2013). Discrete Time Cost Tradeoff for repetitive Items considering Soft Logic. *Journal of Systems Engineering*, *28*(4), 544-561.

Zhang, L., Dai, G. et al. (2020). Robustness-based multi-objective optimization for repetitive projects under work continuity uncertainty. *Engineering, Construction and Architectural Management*, *27*(10), 3095-3113. https://doi.org/10.1108/ECAM-08-2019-0458

Zou, H. B., Zhou, G. H., & Yang, L. (2023). *Application Research of Computers*, *40*(7), 1976-1981.

Zou, X., & Zhang, L. (2020). A constraint programming approach for scheduling repetitive projects with atypical activities considering soft logic. Automation in Construction, *109*(1), 1-10. https://doi.org/10.1016/j.autcon.2019.102990

Zou, X., Wang, R. F., Zhang, L. H., & Qi, J. X. (2022). Research on discrete time cost Tradeoff and Constraint programming Model of repetitive projects with soft logic. *Management Science in China*, (10), 109-118

Zou, X., Zhang, L., & Zhang, Q. (2018). A Biobjective Optimization Model for Deadline Satisfaction in Line-of-Balance Scheduling with Work Interruptions Consideration. *Mathematical Problems in Engineering*, (2018-5-3), 2018(PT.5), 1-12. https://doi.org/10.1155/2018/6534021