Dynamic Control of Integrated Project Management System based on Engineering Projects

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Abstract. This paper adopts a computer-aided method to conduct an in-depth study and analysis of the application of the dynamic control of the comprehensive management system of engineering projects. The application of building information modeling technology in supervision and audit work is discussed in-depth, and combined with actual working experience, the introduction of building information modeling technology into the preparation and implementation of project supervision planning is explored to improve the business level of engineering supervision to meet the actual needs of current engineering construction. Based on the basic theory of engineering supervision and the theory of building information modeling technology, the demand analysis of building information modeling technology is carried out by combining the relevant problems of project supervision planning in actual work. Then, according to the preparation content of project supervision planning, detailed design is made for the key contents of personnel organization structure, supervision audit, and supervision working methods in supervision planning respectively, a supervision team based on building information modeling technology is formed, a supervision audit system based on building information modeling technology is constructed, and the traditional supervision working methods are broken, and building information modeling technology is tried to be applied to project supervision quality. It tries to apply building information modeling technology to the management of quality, progress, cost, and safety of project supervision and realize the partial application of supervision audit system in the actual engineering projects.

Keywords: computer-aided; engineering projects; integrated management system; dynamic control
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1 INTRODUCTION

Economic development and technological innovation are closely related, and the application and development of information technology play a more important role, and from the actual situation, information technology is widely used in the construction industry, agriculture, and finance, which has largely improved the productivity of the industry. The construction industry has a very complex construction process, and there is an insufficient collaboration between the various stages. In the past, under the two-dimensional drawing work mode, the project participants could not effectively share information, mainly because of the relatively low degree of information technology. With the progress of society and economic development, information technology and the concept of sustainable development have received widespread attention and importance, especially in the field of construction. In the study of construction issues, the informatization design of the building runs through the whole construction cycle and has a great impact on the development of the construction industry [1]. The problems and challenges encountered by the construction industry in the process of development deserve greater attention, which has a positive impact on improving the efficiency and quality of construction. In this context, the construction industry has relatively low efficiency and faces extremely serious waste. From the perspective of the actual process of building construction development, the total amount of resources to be consumed during the construction phase of the project is the largest, and at the same time involves complex processes, difficult coordination among the parties involved, and much cost and quality information, which all affect the cost phase of the construction phase. How to apply information technology in the construction industry and how to promote information sharing, many scholars have conducted profound studies on these issues.

Traditional enterprises in the face of project analysis and construction process generally take the mode of two-dimensional collaborative design, with the development of modern society for the level of construction requirements continue to improve this way has been unable to well meet the needs of the modern construction industry, BIM-based building information model analysis in the modern construction industry is also increasing the attention. In the process of analyzing the project construction information, the model can be studied from different perspectives such as schedule, cost and safety and quality, which provides new development ideas and directions for the subsequent development of the construction industry, and the modern construction industry must consider many aspects of information in the process of development, and there may be duplication or omission of information if only relying on the BIM model [2]. The research-based on BIM5D technology in this paper is based on the traditional model analysis with appropriate enhancements, which has a very important role in solving the risks and deficiencies in the real construction industry. At the same time, in the process of research, this paper focuses on theoretical and practical, and applies BIM technology to the actual project cost management, and based on this, completes the model construction for large projects, so that it can be applied to the cost control of engineering project management at a later stage, to improve the management level and cost control ability of enterprises.

In the process of cost management, the project budget data calculated based on construction drawings as the planned cost is generally calculated by the budget clerk, while the actual construction cost data is grasped by the project manager, and there is a certain delay between the two sides in the time node of progress and cost data comparison. The use of BIM technology can realize the selection of the map can calculate the volume of work, more quickly complete the volume of work split and re-summarized, and find out what parts of the project cost increase caused by the project, but also to provide technical support for the work of progress payment. Since BIM technology is introduced in the whole process from project bidding to construction stage of completion settlement, the software management system automatically analyzes the loaded BIM model, classifies and organizes the information data containing cost and progress, analyzes whether the time node of cost input is reasonable according to the comparison of peak and valley values of cost expenditure and physical progress, and carries out the analysis of deviation parts through multi-dimensional graphics in Real-time analysis of deviation areas facilitates the adoption of corresponding measures to correct deviations.

2 CURRENT STATUS OF RESEARCH

Through the analysis of project BIM application results, the combination of its BIM technology and cost management is studied [3]. The BIM information model of project cost management is established, and based on the communication of the BIM platform, the information of materials and components is parameterized with the help of electronic two-dimensional code technology, and the processes of visa management and design changes in the traditional construction process are incorporated into the BIM platform to realize real-time information sharing. The progress front line method and earned value analysis method are used to collect site cost management data to match with the model information to ensure that the model can truly reflect the actual cost management, and then guide the site cost management [4]. The BIM cost control model based on the combination of BIM technology and cost control theory is mainly studied, and the cost control method with BIM technology as the core is fully elaborated from the dimensions of dynamic cost control, design deepening, cost parameterization, and design change cost control. It also combines cost information and WBS process node information to build a BIM 5D model with data layer as the basis, service layer as the core, and interface layer as the result for construction cost control, to achieve the goal of refined cost management, to speed up the transformation of the construction industry, and to effectively promote the reform of enterprises from labor-intensive to technology-intensive direction.

The expert system for building electrical review constructed by Ferreira al. is a typical application of the deterministic reasoning technique [5]. Xu et al. combined tunnel monitoring and maintenance data with a BIM database and used Spatio-temporal data mining techniques and high-dimensional Spatio-temporal correlation analysis methods to analyze the relationship between components as well as diseases [6]. Lachhab et al. studied equipment accidents in the construction industry based on a safety training platform to provide a new and useful solution for safety training in construction operations [7]. Pellerin et al. conducted a comprehensive analysis and study on the control of early project construction costs, and based on this, established a corresponding building information model using H-dimensional modeling and used this approach to study the feasibility and economy of design in project construction, and from the project, appearance was considered [8].

Based on the construction project stage, the project cost is divided into initial stage cost, construction stage cost, and completed operation cost. Project cost accounting plays a crucial role in it, and the realization of project cost accounting depends on the enterprise management style and management level, through project cost accounting, so that the cost expenditure of construction enterprises can be effectively reduced, and it also helps to improve the profit level of the enterprise. The initial stage cost of the project refers to the cost formed in the opening stage of the project, such as the expenditure on preliminary research work. The initial stage cost of the project refers to the costs formed during the opening stage of the project, such as the expenses of preliminary research, planning, feasibility study, planning, and design, etc. The construction phase cost is understood to be the cost of project promotion, such as labor, machinery, materials, management, fees, and taxes to be paid to the tax authorities, as well as the cost of measures. The construction phase cost accounts for more than 90% of the total project cost and is the main object of cost control. The project completion and operation costs can be understood as the costs formed during the project completion stage, and the costs formed during the later stages of the project, such as maintenance fees and acceptance fees.

3 DYNAMIC CONTROL ANALYSIS OF COMPUTER-AIDED INTEGRATED MANAGEMENT SYSTEM FOR ENGINEERING PROJECTS

3.1 Computer-aided Design of Integrated Management System for Engineering Projects

According to the requirement analysis, the system is divided into three parts, including the field information management module, inspection and transfer information management module, and technical operation chart display module. The functions of field transfer information management module include maintenance of operation chart template, management of receiving and dispatching plan and shunting plan; the functions of inspection and transfer information management module include comprehensive management of overhaul plan, management of daily overhaul plan and management of fault repair; the technical operation chart display module is to display all operation plans in the station, including receiving and dispatching operation plan, shunting operation plan and overhaul operation plan. The technical operation chart display module is a display of the operation plans in the station, including receiving and dispatching operation plans, shunting operation plans and overhaul operation plans. To ensure that the enterprise predetermined reasonable profit, to project objectives can be achieved as a premise, the whole staff to participate in a kind of expected cost value is called target cost, target cost value of more sources, can be the project contract price and the project budget in the bid budget cost, can also be the project payment and the project contract price in the project contract price, can be the same period of the project plan value, can also be the actual value of the completed project. Different comparison objects have different target cost values.

For the target cost management in the construction stage, the planned cost based on the enterprise budget quota should be taken as the target cost, and the target cost should be decomposed into corresponding target values according to the project composition as the implementation object and the planned value of cost management, and a variety of management strategies such as scientific and effective cost control, analysis, accounting, and assessment should be used in the project implementation process to realize the control of cost target to achieve prior In the process of project implementation, we use scientific and effective cost control, analysis, accounting, assessment and other management strategies to realize the control of cost target to achieve the whole process control of pre-prediction, real-time tracking and analysis of correction during implementation, and cost accounting, assessment and supervision after implementation [9]. The core of target cost management is to take the target as the guide, decompose the cost target to each sub-component of the project, form the target cost of unit quantity, and find the factors affecting the deviation of the target cost by comparing the expected target cost with the actual cost in the process of implementation, and then seek the way to reduce the actual cost, and provide the basis for the optimization and performance assessment of the cost management system in the later stage, as shown in Figure 1.

The focus of target cost management is to control beforehand, therefore, a complete set of the cost management system is needed to support the enterprise, shift the traditional focus from post-analysis and assessment to ex-ante control, and at the same time strengthen the awareness of cost responsibility with the participation of all employees, incorporate all employees and the whole process of production and operation into the scope of cost management and control, control both the actual cost input and cost expenditure, to ensure the economic benefits of the enterprise and achieve optimal cost efficiency.

In the actual project progress, the project management personnel should be assigned the corresponding management authority and clear information registration requirements, and corrective measures should be taken according to the information reflected in the risk map. The information in the database is updated and adjusted promptly according to the actual progress of construction to make it meet the needs of work. The system is designed to provide some support to project managers in decision making by calculating various risk indices and drawing charts in the background of the system according to the pre-set rules and visualizing the current construction safety risk situation through statistical data and information in the construction process.

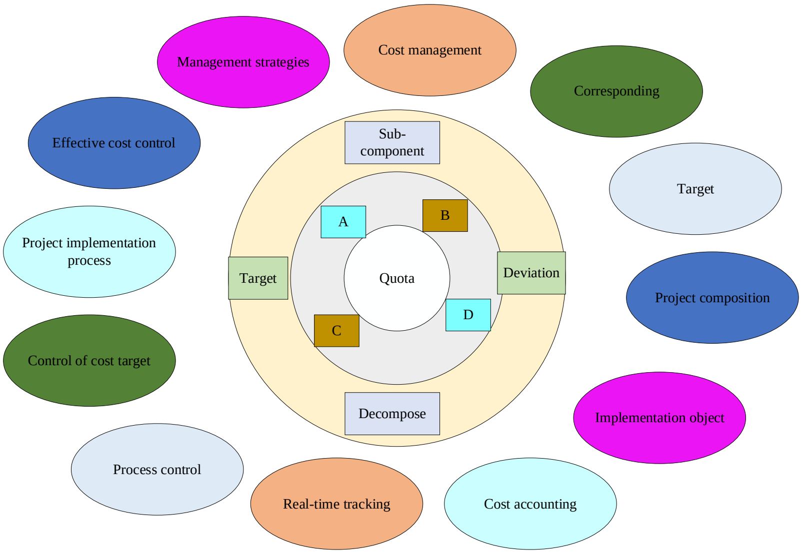

Figure 1: Framework of computer-aided integrated management system for engineering projects.

Traditionally, the management of project cost has a large workload, low efficiency, long cycle time and cannot obtain the analysis results in real-time, so there is a problem of analysis lag, the analysis results are relatively single, and it is easy to cause the problem of cost deviation, and it is not easy to make a judgment according to the actual situation, and the measures are not taken in time. However, the cost management using BIM 5D technology can effectively guide the actual cost management operation, so it is in line with the PDCA concept. The core management elements of multi-objective coordination and control of highway construction projects can be divided into safety management, quality management, schedule management, and cost management. Process inspection, factor analysis, and quality control are the main elements of quality management; influence factor analysis, planning and cycle control are the core of schedule management; cost composition analysis, budgeting, and accounting control are the focus of cost management; information detection, risk assessment, and early warning decision constitute the core elements of safety management, as shown in Figure 2.

The competitive cost plan mainly occurs in the bidding stage or contract signing stage of construction projects, and this kind of cost plan is mostly prepared concerning the bidding instructions, technical requirements, and payment terms and conditions, combined with the actual site survey and the enterprise's consumption of labor, materials and machinery, management level and other cost indicators, etc., and is a kind of estimate of the total cost required to complete the bidding project. Although the budget staff can prepare quotation documents according to the data of similar projects in the past, they are only clear about some of the cost components in the quotation documents, and they are not fully familiar with the missing items and potential risk factors that are not listed in some bidding documents in the construction, such as the coordination and cooperation costs in the electric power installation industry or the pipeline occupation fees when laying cables, which may not be foreseen by the budget staff when making quotations. These factors may not be foreseen when making quotations, resulting in increased costs during project construction.

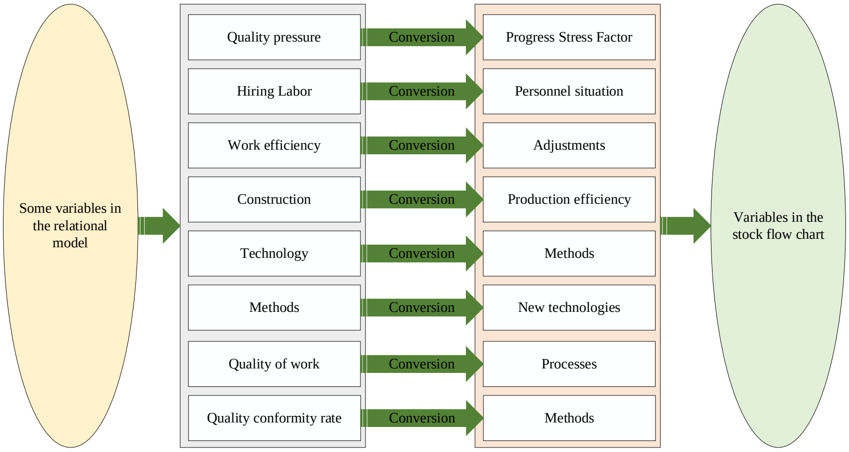

Figure 2: Transformation of variables from a relational model to stock-flow diagram.

3.2 Dynamic Control Analysis Design

BIM technology is used as a tool to assist project construction schedule management, integrate BIM models of different professions, and build the construction model required for the project based on a deepening design model. BIM software can be used to export the corresponding component details by floor or by element attributes, and combined with the construction schedule based on the work decomposition structure, BIM 3D model and time parameters can be interrelated BIM 4D model, based on the 4D model for collision checking and construction simulation and other operations can quickly find out the potential problems in the project, to carry out effective collaborative management and information sharing. By compiling a scientific and reasonable construction schedule, combining with intelligent algorithms to improve the efficiency of optimizing the construction schedule and effectively controlling the actual construction progress of the project, not only facilitates the communication and collaboration of all parties involved in the project but also helps to achieve the project management goal of "good and fast" for construction enterprises. Therefore, BIM technology is reasonably used in project construction schedule management, and the implementation path of construction schedule management based on BIM technology is given, as shown in Figure 3.

The practical application of BIM technology is reflected in five aspects: schedule planning, schedule optimization, schedule tracking, schedule comparison, and schedule adjustment. In the process of preparing the schedule plan of the crosswalk or network diagram, the construction enterprises can realize the comprehensive optimization of project schedule according to the established schedule-cost-quality model, and mainly track the progress, compare, and analyze the schedule deviation during the construction stage, and take measures and adjust the plan according to the actual situation. Since this paper mainly focuses on the schedule management of construction enterprises, the BIM technology-based construction schedule management platform conceived is proposed after considering the whole actual construction schedule management process of the project and combining the traditional schedule management theory and content. A platform is a key tool for collaborative project construction schedule management based on the BIM model, which is expected to be able to prepare, adjust and query the construction schedule; to realize the project schedule control by tracking the progress collection information, comparing, and analyzing the schedule deviation and adjusting the schedule; and to ensure the linking, updating, and maintenance of the BIM model.

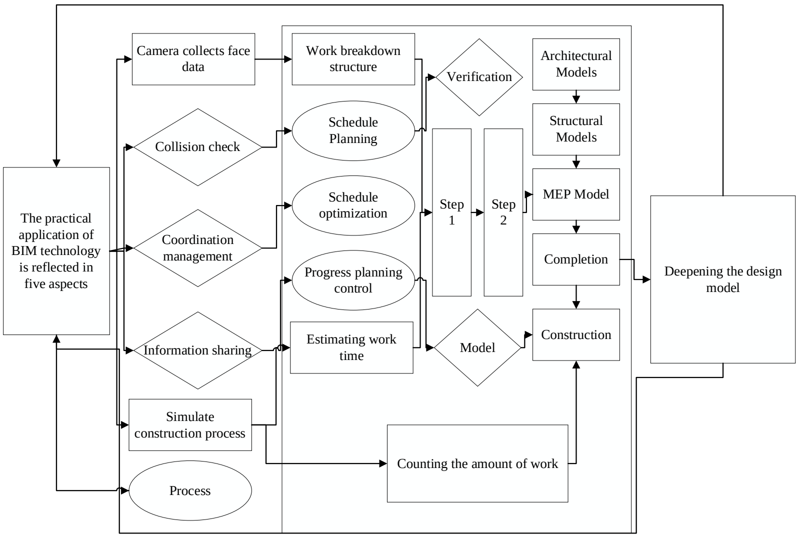

Figure 3: Construction schedule management implementation path dynamic control.

Firstly, the required schedule is exported based on the BIM model, that is, according to the requirements of the unit project construction schedule, the required schedules are exported by setting the filter conditions and counting the quantity of each layer of components; secondly, the WBS decomposition of the project is carried out according to the requirements of the unit project construction schedule, and the bill of quantities of each layer is processed, specifically by merging similar components. The same kind of work, delete the project characteristics and keep the project name, unit of measurement, quantity of work and add the project number, and adjust the construction sequence of each work according to the construction process, then classify the non-physical work and estimate its workload, and form the preliminary WBS decomposition table by refining and adjusting the model components and listing them according to the content of the project. The relevant information of the project is added and improved, but not all the non-physical work is compiled into the unit construction schedule, and the work that does not affect the critical line can be appropriately combined or omitted to form the formal WBS breakdown table.

The construction schedule optimization of the project is to achieve the comprehensive optimization of the project's schedule, cost, and quality objectives, and no longer considers only the schedule objectives at the expense of the project's cost and quality. Despite the existence of non-linear, vaguely defined, and other complex relationships among the three there exists the best construction plan with relatively short duration, low cost, and good quality. Based on the analysis of the theory of traditional schedule optimization and combined with the actual situation of the project, it is assumed that the construction resources of the project are adequately supplied; the research data are derived from the discrete data of the project, thus constituting a three-dimensional discrete space; the construction process of the whole project consists of different construction operations, each operation has at least two construction operation solutions to choose from and only one of them can be chosen each time, and the construction operation solutions of each time, cost and quality parameters of each construction operation plan are different, as shown in Figure 4.

The positive progress deviation indicates that the actual progress is earlier than the planned progress, the situation can give full consideration to the continuous balance of the supply and use of construction resources, and increase the virtual work at the appropriate time point if necessary if the conditions allow the advance time difference can be used as a backup resource to cope with the schedule risk, which can buffer the schedule delay caused by the occurrence of unexpected circumstances in the subsequent operations if the project construction task can be completed successfully and early, it is beneficial to The construction enterprise can obtain more profit if the project can be completed early; adjust the duration of each work on the key line, that is, shorten the duration of the work as much as possible without changing the logical relationship between construction operations [10]. The most common way to catch up is to add extra workforce, materials, equipment, and other resources to ensure the construction duration by working overtime, but this will inevitably lead to related conflicts. Therefore, scientific organization of important non-critical construction operations and reasonable deployment of various construction resources are required.

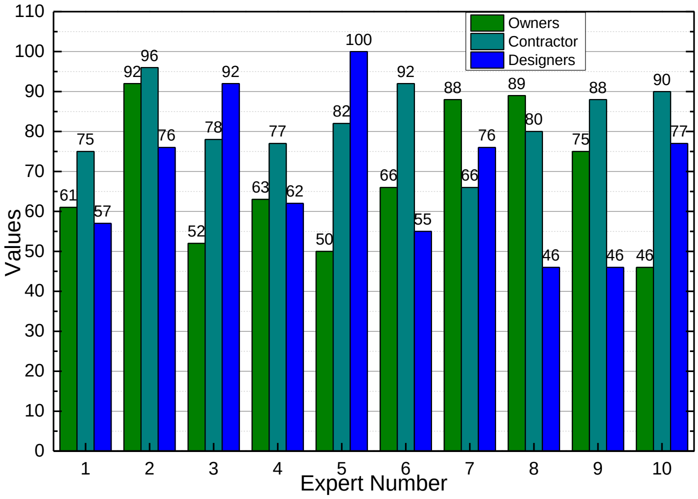

Figure 4: Evaluation of the weight of each environmental condition regulation impact by the project participants.

Here the logical relationship between the work refers to the organizational relationship between them rather than the process relationship, in adjusting the construction mode and construction sequence of each operation to reconsider and plan. For example, the often-used flowing construction can be adjusted to parallel construction to finish as soon as possible, and the construction operations that meet the process requirements can be lapped as far as possible to shorten the construction period. The "schedule plan" function module in the construction schedule management platform based on BIM technology is designed to realize the preparation, adjustment, and query operation of the construction schedule of the project. By finding the relevant information of the project, according to the proposed BIM technology-based construction schedule preparation process, the construction schedule of the project is formulated, and the schedule control of the project is implemented based on the PDCA cycle during the construction process, and the schedule plan can be quickly adjusted according to the actual situation of the project, and the query function is used to help the person in charge of schedule management to organize and file the project schedule information.

4 ANALYSIS OF RESULTS

Using the BIM5D information integration platform, the construction unit made a detailed construction schedule, machinery, and equipment entry and exit plan and material supply plan concerning the progress data of similar projects completed in the historical database and other project information, and used Quanta Zebra schedule software to develop a detailed construction schedule, machinery and equipment entry and exit plan and material supply plan, combined with the total cost expenditure plan and decomposed it to measure the daily planned cost of each part and generate the cumulative cost expenditure data. Taking the transmission line road sub-unit project as an example, firstly, the schedule plan of this sub-unit project was prepared according to the project target decomposition data, as shown in Figure 5. According to the project's daily input of labor, materials and equipment, machinery, capital, etc., calculate the daily construction cost, and prepare the cost expenditure plan my time on the time scale network diagram. Calculate the number of costs planned to be spent cumulatively for a certain period, the transmission line road subunit project to do a cumulative calculation every five days, and then use the cost amount cumulative calculation formula to sum. As the project progresses and is implemented, the funds and resources invested in the physical project, as well as changes that occur on-site and changing market material prices, are compared to the cost plan values. By maintaining the model data in real-time, the updated quantity information is automatically obtained by applying BIM software.

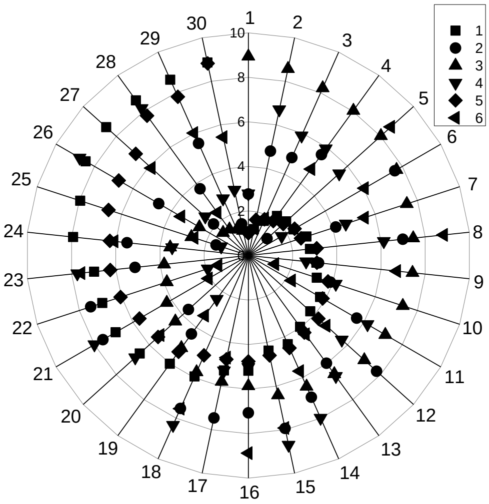

Figure 5: Unit project cost expenditure plan.

Through the timely entry of market unit prices, the application of BIM software can realize the recording and dynamic analysis of the cost. Real-time guidance, supervision, inspection, and regulation of the human, material, and machine resources and other extra-contractual expenditures such as subcontracts invested in the implementation of the project. The deviations that have occurred are analyzed in data, and then various means such as organizational and technical measures and contractual economic measures are used to correct the deviations generated on time. In addition, the platform's contract information entry function is used to record extra-contractual expenditures and income on time, ensuring the integrity of project cost information and providing a basis for the later project settlement for easy access.

It is possible to control different soft processes internally and improve the adaptability of the technology, so it is possible to complete the parallel work mode and build the corresponding operation process according to the actual demand output and information input, and at the same time, to effectively ensure the authenticity and stability of the data, it is possible to determine the type of data to be used in the analysis and research of the actual problem, and then, based on this analysis objective. To ensure the subsequent application of the software, the problems and shortcomings of the software should be studied, and the optimization and upgrading of the software should be completed from various aspects, but this process is still troublesome for the operation of the enterprise, as shown in Figure 6.

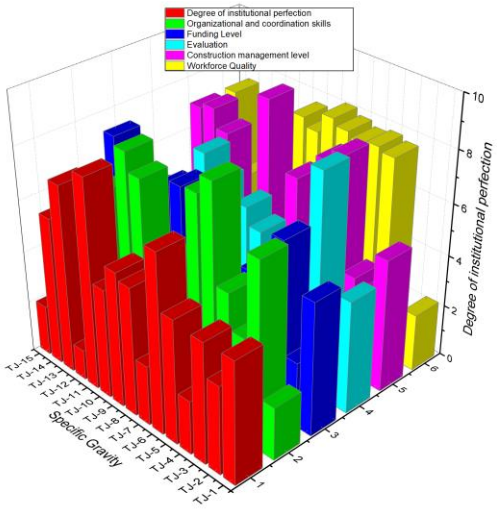

Figure 6: Evaluation value of project participants in each bid section.

The estimated progress delay rating level of the tender sections is higher, and the natural and social conditions rating levels of these tender sections are generally higher, especially the social conditions rating level is above 3, and the social conditions rating level of the tender sections even reaches 4. While the contractor's role in regulating social conditions is greater, the design unit's role in regulating natural conditions is greater. Given such environmental conditions of the project, we can focus on the supervision and control of the contractors and design units in the sections with a higher rating of progress delay to improve their ability to regulate the social and natural conditions, to reduce the risk of progress delay.

Traditionally, the material requirement plan needs to be prepared by several departments, and the construction technicians make preparation calculation according to the drawings, submit to the material department for inventory comparison by the material specialist, and then prepare the material requirement plan to guide the site material collection after summary analysis. However, this traditional model has greater limitations, and the technical level of personnel is the dominant factor. Sometimes, the progress plan often changes frequently because the material calculation of drawings is not in place, resulting in an inaccurate final material demand plan. Sometimes the material planning personnel often also leave a considerable margin of material loss, leading to problems such as too much material remaining in the field operation, as shown in Figure 7.

The management of project quality in the implementation stage is to supervise the contractor to construct with drawings, specifications, rules, and standards according to the entrustment of the investor and the construction contract of the construction project so that the construction and installation can be carried out in an orderly manner and finally form a qualified project with complete use-value. The backup of drawing documents and the on-site comparison of Revit models at the construction drawing level can play a very important role. The Revit model combined with the timeline can realize 4D progress control management, and the Navisworks platform associates the model with time and cost so that the planned progress and actual progress can be displayed in the platform. The Navisworks platform associates the model with time and cost and can display the planned and actual progress in the platform, which can realize the dynamic control and timely correction of the construction stage. The focus of cost control is on the use of funds plan, project measurement and payment audit, quotation, and verification, changes, claims, and visas in the project, and dynamic information management of project cost. In the cost control, we combine the

BIM5D method to control the capital plan, and for engineering changes, we can use different versions of model files to keep the changes.

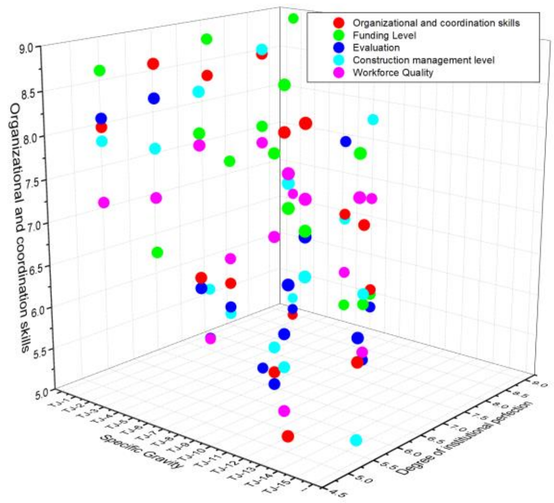

Figure 7: Initial and end states of the main program.

5 CONCLUSION

With the development of society, people's demand for construction is also increasing, and with the increasing amount of engineering and design requirements, the traditional two-dimensional collaborative design can no longer meet the actual design and construction needs. Therefore, this thesis is based on the development needs of the modern construction industry, taking the way of coordinating multiple software to complete the overall design of the project, and analyzing from the perspective of project schedule, cost, and construction safety, using BIM5D to analyze the model information and design to generate the corresponding 4D simulation, to lay a solid foundation for the subsequent construction, and also importing various professional models in the construction design process into the software to form an integrated BIM5D model can be used to integrate different information in the project, which can provide effective guidance and reference for the subsequent construction, and through the simulation construction, the problems and deficiencies in the construction process can be found better and the optimization of the program can be completed. The research based on BIM5D technology is a step forward from the traditional model analysis, which has a very important role in solving the risks and shortcomings in the real construction industry and has a positive impact on promoting the development of the modern construction industry.

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REFERENCES

[1] Temel, B.-A.; Başağa, H.-B.; Temel, M.-U.; Yılmaz, G.-K.; Nasery, M.-M.: Big Room concept in project management and control, Journal of Construction Engineering, 2(4), 2019, 204-214. https://doi.org/10.31462/jcemi.2019.04204214

[2] Sampaio, A.-Z.: BIM as a computer-aided design methodology in civil engineering, Journal of software engineering and applications, 10(2), 2017, 194-210. https://doi.org/10.4236/jsea.2017.102012

[3] Léonard, G.; Belboom, S.; Toye, D.; Dumont, M.-N.; Léonard, A.; Heyen, G.: Recent Evolutions and Trends in the Use of Computer Aided Chemical Engineering for Educational Purposes at the University of Liège, Computer Aided Chemical Engineering, 40, 2017, 2941-2946. https://doi.org/10.1016/B978-0-444-63965-3.50492-X

[4] Li, J.; Sun, M.; Han, D.; Wu, X.; Yang, B.; Mao, X.; Zhou, Q.: A governance platform for multi-project management in shipyards, Computers & Industrial Engineering, 120, 2018, 179-191. https://doi.org/10.1016/j.cie.2018.04.026

[5] Ferreira, N.; Santos, G.; Silva, R.: Risk level reduction in construction sites: Towards a computer aided methodology–A case study, Applied Computing and Informatics, 15(2), 2019, 136-143. https://doi.org/10.1016/j.aci.2018.01.003

[6] Xu, X.; Zou, P. X.: System dynamics analytical modeling approach for construction project management research: A critical review and future directions, Frontiers of Engineering Management, 8, 2020, 1-15. https://doi.org/10.1007/s42524-019-0091-7

[7] Lachhab, M.; Béler, C.; Solano-Charris, E.-L.; Coudert, T.: Towards an integration of systems engineering and project management processes for a decision aiding purpose, IFAC-PapersOnLine, 50(1), 2017, 7266-7271. https://doi.org/10.1016/j.ifacol.2017.08.1379

[8] Pellerin, R.; Perrier, N.: A review of methods, techniques and tools for project planning and control, International Journal of Production Research, 57(7), 2019, 2160-2178. https://doi.org/10.1080/00207543.2018.1524168

[9] Zhang, S.; Pan, F.; Wang, C.; Sun, Y.; Wang, H.: BIM-based collaboration platform for the management of EPC projects in hydropower engineering, Journal of Construction Engineering and Management, 143(12), 2017, 04017087-04017087. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001403

[10] Baiardi, L.; Ferreira, E. -A.: The Integrated Project for the Redevelopment of a Historic Building: An Example of BIM and IoT Integration to Manage the Comfort of the Building, In Impact of Industry 4.0 on Architecture and Cultural Heritage, 2020, 261-282. https://doi.org/10.4018/978-1-7998-1234-0.ch011