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Research on Intelligent Calculation Method of Building Cost Management Supported by BIM Based Multi-Intelligent Body System

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ABSTRACT

In order to realize the intelligent calculation of cost management during the implementation of construction projects, this paper proposes a methodological architecture based on Multi-intelligent Reinforcement Learning (MARL) and Building Information Model BIM. The construction cost management problem of the project is analyzed with examples in order to optimize the construction cost management and construction time management of ZZYH comprehensive business building. The results of the study show that a reasonable rebar path can be found through 40 independent simulation verifications, and the final convergence reaches 100%. Compared to manual savings, the collision-free rebar design using the computational framework of BIM and multi-intelligence saves roughly 90% of the time. In terms of optimizing the construction cost management of civil engineering, installation engineering, cable engineering, and overhead line engineering, the total amount of cost savings of the project amounted to 382,320,000 yuan.

Keywords: multi-intelligent body, BIM model, cost management, intelligent calculation

1. Introduction

With the advancement of national modernization, the city to create a new environment suitable for the face, focus on internal reform and construction, the number of construction projects increased during this period, the construction and development of the city have an important role in promoting. Engineering cost has always occupied an important position in the construction of construction projects, is the key to whether the cost of construction input can meet the construction requirements [1]. Engineering cost industry in the process of increasing construction projects, undertake a large number of tasks, but will be due to the problem of outdated control methods, in the cost control problems, for a lot of work in the construction, are difficult to control with the help of scientific methods [2-5]. Therefore, the enterprise in order to implement the cost management task, on the

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basis of grasping the main points of cost management, intelligent technology as the core, optimize the cost management mode, so that it is in the control of all kinds of work in the project, to achieve the purpose of solving the construction cost, reduce unnecessary cost expenditure [6-10]. Engineers in the use of intelligent technology, the engineering parameters into the computer software, the establishment of the corresponding model, so as to achieve the cost control of the whole life cycle of the construction project, when the cost management objectives, in order to achieve the business objectives set by the construction enterprises [11-13].

With the continuous progress of science and technology, the application of building information modeling (BIM) technology has become more and more widespread.BIM technology provides an integrated and visualized management tool in the whole life cycle of a building through digitalization [14]. In engineering cost management, the introduction of BIM technology provides unprecedented convenience for refined management. The traditional way of engineering cost management is often cumbersome and inefficient, while the use of BIM technology can greatly improve the efficiency and accuracy, making the engineering cost management more refined and scientific [15-18]. In addition, the establishment of the multi-intelligent body system enables the establishment of communication mechanisms between intelligent devices, which can cooperate with each other to solve complex tasks that cannot be accomplished by independent devices [19-20]. In addition, the data collection and analysis of each link of work, the establishment of a database to meet the needs of cost management, can quickly organize the data related to the project, based on the information of the construction project, decision-making and judgment [21-23]. BIM technology based on multi-intelligent body system supports the construction cost management method to intuitively understand the details of the project, so as to achieve precise control in cost management, reduce waste, and contribute to the sustainable development of the construction industry [24-26].

The construction project cycle is long, divided into numerous stages, each stage of the work has a lot of engineering volume, the use of BIM technology gives a control method on the cost aspects of the project, which has a certain degree of effectiveness. In the investment estimation stage, through the effective use of BIM technology, the future investment costs required for the project can be accurately estimated. Literature [27] points out that the lack of data makes the cost estimation in the conceptual stage of a construction project have a large error, while the application of BIM technology develops an architectural standard for the project, so that the modeling process is carried out efficiently in accordance with specific rules, which significantly reduces the human error in the cost estimation and reduces the estimation error. Literature [28] investigated the automation of cost estimation and BIM integration in the architectural, construction, and operations industries, where BIM technology provides an information management platform for designers, architects, and cost estimators that significantly improves the efficiency and transparency of the industry. Literature [29] analyzed the feasibility of BIM technology for assessing the value of investment and return on investment by quantifying the economic benefits in construction projects, which can effectively help practitioners to overcome the constraints associated with BIM investment and economic assessment in the construction industry. Literature [30] emphasizes the importance of accurately estimating the pre-costs of construction projects, and proposes a cost assessment method based on BIM technology and virtual reality technology, which provides solid technical support for project cost management through rapid and highly accurate adjustments and updates. Literature [31] shows that BIM, as a multidisciplinary integration tool, can effectively solve the information collection, team communication, and design and construction problems that affect the accuracy of the initial cost estimation of construction projects, which can help to reduce the errors and improve the cost estimation of future projects.BIM technology itself has the storage function and the staging function, which acts as a large-scale project database in the construction of building projects, and it can serve as a reference for the managers' Provide reference for decision making and accurate estimation of investment cost and future revenue of engineering projects.

It has become a general consensus to use BIM technology in the bidding stage of engineering projects for the accurate measurement of engineering quantity. Literature [32] evaluates the advantages of BIM technology in the bidding stage of construction projects, which can not only improve the bidding efficiency of construction projects by standardizing the bidding workflow, but also solve the conflict of interests of the bidding parties through the calculation of prices, which is of important guiding significance. Literature [33] examined the applicability of BIM technology in the cost estimation of construction project bidding, compared with manual estimation methods, it effectively improves the accuracy of the cost estimation before the bidding process, and plays a vital role in the bidding stage. Literature [34] proposes a calculation method for cost estimation in the bidding stage of construction projects, i.e., the BIM5D model, and identifies the risks in the application of the technology, aiming to improve the accuracy of cost estimation calculations in the bidding stage.The BIM technology can clarify the construction requirements and material data in the bidding for engineering projects, and guarantee the scientificity and completeness of the compilation of costing programs.

In this stage of project construction, BIM technology can dynamically analyze the changes in market material prices, realizing the refined management of construction costs. Literature [35] used BIM model and BIM5D software to establish a complete construction progress management mode, based on which it is possible to clarify the capital and other needs of the construction plan, and at the same time, monitor the cumulative amount of the actual use of funds as well as the amount of deviation from the budgeted funds. Literature [36] establishes a BIM-based construction decision-making framework to support construction project management decisions from four aspects: schedule, cost, quality and safety, with the help of platform information monitoring. Literature [37] investigated the drivers of using BIM technology for quantity surveying during the construction phase, which combined with related tools such as 3D software allows for detailed cost estimation in quantity surveying practice. The use of BIM technology for the refinement of the calculation of project quantities and unit prices of materials, in addition, combined with the requirements of the construction progress of the project to carry out accurate procurement, effectively avoiding the overpayment and delayed payment of the project. In addition, BIM technology can be combined with artificial intelligence, machine learning, cloud computing and other technologies to build a multi-intelligent body system to achieve more efficient construction model generation, design optimization and conflict detection.

In this paper, 3D model information-based BIM technology is utilized to extract data from the whole life cycle of a building. Combined with the Multi-Intelligent Body System, a set of intelligent calculation methods for building cost management combining BIM and Multi-Agent, a core theoretical branch of artificial intelligence, is proposed. Taking ZZYH Comprehensive Business Building as the provincial key project as the research object, the BIM technology based on Multi-Intelligent Body System is utilized to simulate from the whole process of building construction. The effectiveness of BIM technology of multi-intelligent body system is verified through 40 independent simulations. And compare before and after the optimization, the changes in project cost and duration, etc., to discuss the utility of this paper's method for cost management from the perspectives of qualitative analysis and quantitative testing.

2. Building data information extraction with BIM technology

With the creation and continuous development of computer technology, the traditional construction industry has changed dramatically. The traditional manual hand-drawn drawing paper was replaced by CAD computer-aided design, which is known in the industry as the first revolution in the construction industry. Compared with hand-drawn paper, CAD drafting in terms of accuracy, drawing efficiency and other aspects have been greatly improved, so that architects can focus more on the optimization of the design plan, CAD from the generation of the construction industry has been in the design tools to occupy a dominant position. With the continuous development of computer technology, such as: SketchUp, Rhino and other three-dimensional modeling software, more intuitive embodiment of the spatial relationship of the architectural design and the overall effect of the CAD combined with 3D modeling design approach is recognized by the construction industry, and is widely used. With the continuous development of technology and the increasingly diversified needs of society, the scale of architectural projects is gradually expanding, and the complexity of architectural space is also getting higher and higher. Due to the low level of information utilization of CAD two-dimensional drawing, there are problems such as information dispersion, poor intra-professional synergy, and inter-professional synergy in the process of project design, which seriously affects the quality of architectural design and the progress of the project. As the existing architectural design methods are becoming more and more difficult to meet the needs of increasingly complex construction projects, BIM technology has arisen as a result.

BIM technology will be the future of computer-aided design, and its development trend is shown in Figure 1. With a large number of companies and scholars carrying out relevant research and practical work around BIM, the research and application of BIM has developed greatly and is widely used in various fields of the construction industry. Autodesk, Bentley, Graphisoft and other large international software companies have launched their respective BIM software, and the advantages of BIM technology have gradually emerged in the construction industry. The transition of architectural design from 2D design information based on CAD technology to BIM technology based on 3D model information has been called the second revolution of the construction industry, bringing a new working mode and method for the whole life cycle of construction projects.

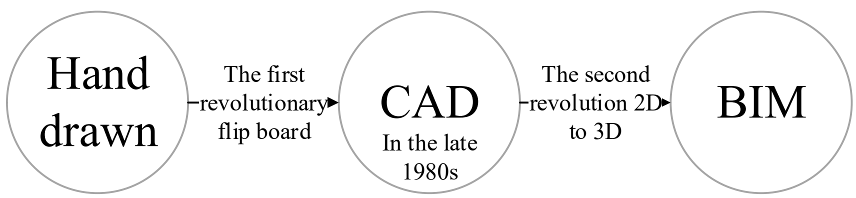

Fig. 1. Development trend

BIM is not only a simple 3D building model, it can be applied in the whole life cycle of the building, the data information it contains is the key, BIM through the project from the early decision-making stage, to the design stage, construction stage, until the late stage of the operation and maintenance of the uninterrupted dynamic data creation and collection, will be the whole life cycle of the construction project contains the information and data, the personnel can through their own needs to view and analyze the information. All parties can view and analyze the information through their own needs. It can be seen that the data expression and information sharing for the whole life cycle of the building is the core of BIM technology, and the load information, physical information, and material information in the BIM model are extracted and used as inputs for the structural type analysis and structural stress analysis modules. Load information is the load condition of concrete members, physical information is the support condition and geometric properties of concrete members, and material information is the grade of concrete, strength of steel reinforcement, and so on.

3. Calculation process of the Multi-Agent simulation model

3.1. Basic Theory of Multi-Agent Technology

A Multi-Agent System (MAS) is a collection of multiple Agents, which cooperate, communicate, coordinate, mutually solve, schedule, control and manage each other to achieve certain goals or work together to solve certain tasks. It is a distributed autonomous system for complex, open, large-scale, dynamic, asynchronous distributed systems.MAS is also an integrated system, which uses information integration technology to integrate the information of each Agent subsystem to complete the integration of complex systems, with distribution, autonomy, coordination, and also has the ability of self-organization, reasoning, and learning ability. The use of MAS to solve real-life application problems has strong reliability and robustness, as well as high problem solving efficiency.

This model is based on the six steps described in the previous interaction rules between each Agent, which are transformed into specific computational expressions to realize the model building of the simulation. The specific content is shown in Figure 2.

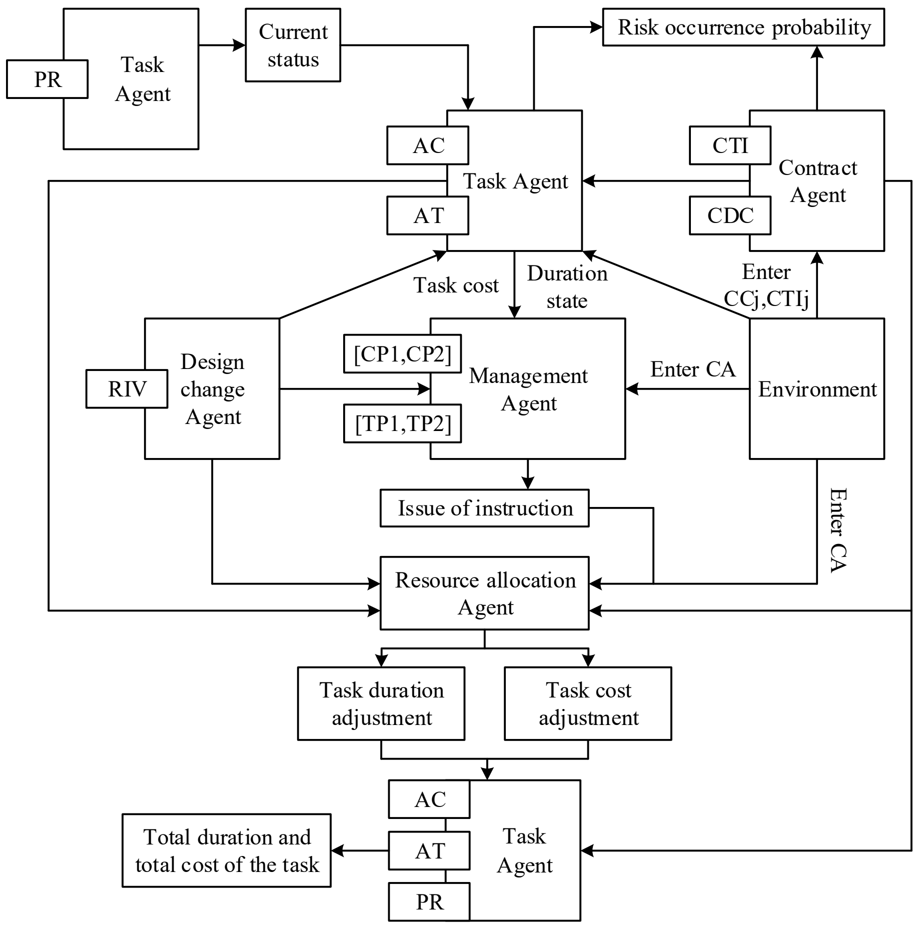

Fig. 2. Interaction rules between agents

3.2. Calculation of task costs, completion of work schedule

1) Task Cost Completion Degree. The degree of completion of the task currently being performed Sta_i (State), where cost completion Sta_C, indicates an analysis of the current use of the cost. Compare the actual consumed cost AC (in the currency determined by the actual transaction of the project, and the same for other parameter units involving costs) before the task risk occurred with the consumed cost after adding the cost of implementing the risk countermeasures and making the task adjustments on the basis of the contract provisions. For example, the implementation of the construction phase of the task, the contract stipulates that the average daily consumption cost of the task 200,000, the duration of the task lasts 35 days, the risk response measures to increase the cost of 5%, 1% of the duration of the task, the actual use of the cost of 7.4 million, that is, $Sta_C = 0.997 < 1$, which indicates that the cost of completion of the current task is a balance.

Comparison between costs is the current cost completion of the task:

$$Sta_c = \frac{AC}{CTI \times CTIj \times PR \times CDC} \tag{1}$$

$$CDC = \frac{CC \times CCj}{CTI} \tag{2}$$

When $Sta_C < 1$, it means that the cost of the task currently being performed has a balance: when $Sta_C = 1$, it means that the current cost of the task has reached the upper limit. When $Sta_C > 1$, it means that the current cost of the task being performed is overrun and cost control should be strengthened: the larger the value of Sta_C, the more cost control should be strengthened. AC indicates the actual consumed cost value of the task currently being executed. CC denotes the cost of tasks consumed under the contract. CDC indicates the average daily consumption cost assigned to the task under the contract: CTI indicates the time consumed by the task under the contract: PR indicates the current progress of the task, expressed as a percentage.CTI¡ indicates the value of the correction of the duration by the risk response measures, and CCj indicates the value of the correction of the cost by the risk response measures, which can be determined by the specific measures in conjunction with the actual project.

2) Task Duration Completion Degree. The degree of completion of the duration of the task that is currently being executed Sta_T, by comparing the actual duration AT consumed by the task with the CTI of the adjusted duration of the task with the addition of risk countermeasures on the basis of the contract provisions:

$$Sta_T = \frac{AT}{CTI \times CTIj \times PR} \tag{3}$$

When $Sta_T < 1$, it indicates that there is a balance in the duration of the task currently being executed. When $Sta_T = 1$, it means that the current duration of the task has reached the upper limit. When $Sta_T > 1$, it means that the current duration of the task is overrun and the duration control should be strengthened. The larger the value of Sta_T, the greater the need to strengthen the control of the duration. AT indicates the actual amount of time consumed by the current task. CTI indicates the amount of time stipulated in the contract for the task. PR indicates the current progress of the task, expressed as a percentage. CTIj indicates the corrected value of the duration by the risk countermeasures.

3) Cost and Duration Preferences PV_i. Invite project experts or project managers to make a judgment on the cost and schedule preference by using any number from 0 to 1 (two decimal places). 0 means very dissatisfied, 0.5 means general, and 1 means very satisfied. Here will be each preference value gift assembly interval into the model, through the system of random selection way to better simulate each person's thinking and ideas.

4) Adjustment of task duration. The task execution period is affected by the design change risk events, the task manager will make corresponding adjustments to the duration of the subsequent task STT:

$$ST_T = \left(CTI \times CTIj - AT\right) \times \left(1 + CF_T - \left(RIV + CA\right)\right) \tag{4}$$

Here CTI denotes the amount of duration specified in the contract for the task. AT denotes the amount of actual duration consumed by the current task; PR denotes the current progress of the task, expressed as a percentage. CFT denotes the correction factor for duration by the task manager. RIV denotes the impact of the risk event, $RIV \in [-1,1]$. CA denotes the extent to which the risk response corrects for the impact of the risk, $CA \in [-1,1]$.

The duration correction factor CF_T is influenced by the duration directive Ord_T. Due to $Ord_C + Ord_T = 1$. when managers consider cost and duration to be equally important:

$$Ord_C + Ord_T = 0.5 \tag{5}$$

$$CF_T = 0.5 - Ord_T \tag{6}$$

5) Adjustment of task costs. Task managers who are affected by risk events during the execution of a task will adjust the average daily cost ST_C of subsequent tasks accordingly:

$$ST_C = CDC \times \left(1 + CF_c + CF_r - (RIV + CA)\right) \tag{7}$$

Here CDC represents the average cost per day of consumption assigned to the task under the contract, which is obtained by dividing the contracted task cost by the task duration. CF_C, CF_T denotes the correction factor of the task manager for the cost and duration. RIV denotes the impact brought by the risk event, $RIV \in [-1,1]$. CA denotes the degree of correction of the risk impact by the risk countermeasures, $CA \in [-1,1]$.

The cost correction factor CF_C is the same as the duration correction factor CF_C The principle of calculation, is as follows:

$$CF_C = Ord_C - 0.5 \tag{8}$$

6) Total task duration, total cost. The total duration of the task currently being performed TT_T, including the actual duration before the design change risk event AT and the duration adjusted by the risk impact ST_T:

$$TT_T = AT + ST_T \tag{9}$$

The total cost of the task currently being performed TT_C, including the actual consumed cost AC before the design change risk event and the cost adjusted for the risk impact ST_C:

$$TT_C = AC + ST_C \times ST_T \tag{10}$$

4. Optimization analysis in project cost management

4.1. Project Profile

ZZYH Comprehensive Business Building is a provincial key project, located in the CBD sub-center of Zhengdong New District, Henan Province, with 4 floors of podium, 4 floors underground and 22 floors above ground, about 100 meters high, with a total floor area of about 90,000 square meters, and the structure type of frame-core tube structure. There are many participants and it is difficult to manage.

The project is surrounded by subway lines and tube corridors, the construction site is narrow and the environmental conditions are complicated. The project is surrounded by a lake with a high water table, making construction difficult and demanding. Therefore, the project is taken as a pilot project for the application of BIM technology construction cost management of multi-intelligent body system to simulate and optimize the construction plan. Based on the progress and volume of the project, the material resources are automatically analyzed to ensure the construction period and reduce the waste of materials, which initially realizes the digital control of the construction cost of the project.

4.2. Construction Time Management Optimization with BIM Technology Based on Multi-Intelligent Body System

In order to validate the effectiveness of the computational framework based on BIM and multi-intelligentsia proposed in this paper, experiments are conducted on reinforced concrete beam-column nodes, two-story reinforced concrete frames in projects, and multiple complex conditions in real projects, and the experimental results, including the generated rebar paths, success rate, time spent, and cost control confirm the effectiveness of the proposed method architecture.

To ensure the validity of the experimental validation, 40 independent simulation validations are conducted for each experimental case, and each validation includes 1000 training generations. To ensure the independence of each simulation validation, the knowledge experience stored in Q-Table is zeroed out in each simulation.The average success rate of 40 independent simulation validations (each validation includes 1000 training generations), the simulation experiments are shown in Fig. 3.With the training, the multi-intelligence body gradually finds the reasonable rebar path, reaches the end point without collision, and finally converges to 100%. It shows that the proposed computational framework based on BIM and multi-intelligent body reinforcement learning successfully realizes the obstacle avoidance design for building rebar arrangement.

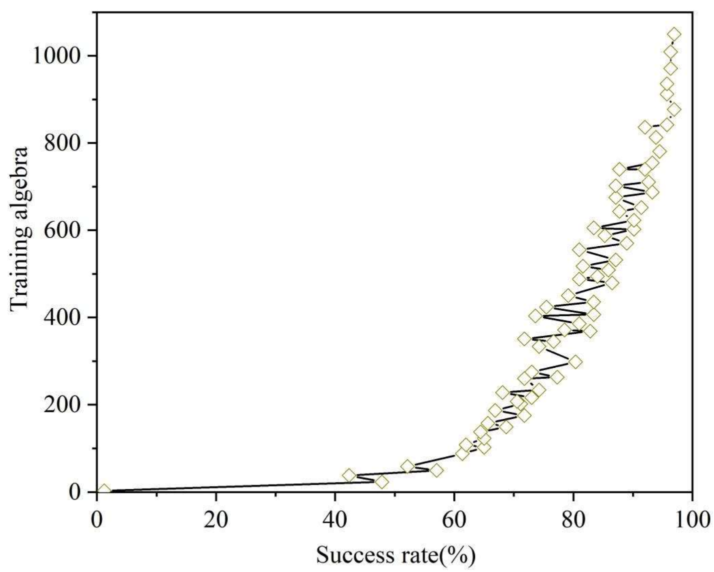

Fig. 3. The success rates of the MARL system

The average time (in minutes) spent on comparing the paths generated by Multi-Intelligent Reinforcement Learning MARL for the design of reinforcement bars within reinforced concrete members with the average time (in minutes) spent by engineers modeling manually is shown in Table 1. A total of 40 structural engineers were invited to participate in this experiment. These structural engineers have more than two years of engineering experience and are from design institutes or engineering consulting organizations. In this experiment, the invited structural engineers were asked to design the reinforcing bars for various types of structures such as L-shaped beam-column nodes, top floor T-shaped beam-column nodes, and intermediate floor cross-shaped beam-column nodes, etc., and then build a collision-free reinforcing bar model in Autodesk Revit and record the time spent. For the time spent on manual collision free reinforcement design for two story reinforced concrete frames, the time spent was measured based on the previously recorded time spent on different structural types as the amount of work spent on all manual reinforcement modeling was too much.

Table 1. The average cost time of structural engineers is compared

Structural type	Component attribute	Average spending time (min))	
		Multi-intelligent body reinforcement learning	Structural engineer
column	500×500mm, 20 longitudinal reinforcement	1-3	6-10
beam	500×300mmand 12 longitudinal reinforcement	1-3	6-10
L beam node	500×300 mm24 longitudinal reinforcement	4-5	12-16
T beam node	500×300 mm24 longitudinal reinforcement	4-5	22-32
Cross beam node	500×300 mm24 longitudinal reinforcement	4-5	22-32
Top single column	500,500mm,500mm,32 longitudinal reinforcement	4-5	22-32
Top l column	500×500,500mm×444 longitudinal steel bars	6-7	32-42
The top side of the column	500×500mm,500mm×32 longitudinal reinforcement	6-7	32-42
The top t beam node	500×500,500mm×444 longitudinal steel bars	6-7	52-62
Top cross	500×500,500mm×444 longitudinal steel bars	6-7	52-62
Single column single column	500×500mm,500mm×32 longitudinal reinforcement	4-5	22-32
L column	500×500,500mm×444 longitudinal steel bars	6-7	32-42
The middle layer reverse beam column node	500×500mm,500mm×32 longitudinal reinforcement	4-5	32-42
The middle layer t beam column node	500×500,500mm×444 longitudinal steel bars	6-7	52-62
The middle layer of the cross beam column	500×500,500mm×444 longitudinal steel bars	6-7	52-62
Two layers of reinforced concrete	110 beams, 46 roots, 2240 longitudinal reinforcement	200-220	3000-3500

The results are shown in Fig. 4, and it can be seen that for collision-free reinforcement design, the average time spent by Multi-Intelligent Body Reinforcement Learning MARL is much lower than that spent by the structural engineers for manual buildup. For example, for the experimental reversed beam-column nodes, T-shaped beam-column nodes and cross-shaped beam-column nodes (beam cross-section size of 500 × 300 mm and column cross-section size of 500 × 500 mm), the average time spent by the multi-intelligentsia reinforcement learning MARL is 6-7 minutes, whereas the structural engineers will spend 52-62 minutes for each beam-column node for rebar design and modeling manually. Moreover, the methodological framework proposed in this paper can provide fast and accurate collision-free rebar design. For the double-story beam-column node (110 beams, 46 columns, and 2240 longitudinal bars) tested in this experiment, the proposed methodology framework takes about 200-220 minutes to generate collision-free rebar designs, whereas a structural engineer would need to spend 3,000-3,500 minutes to design the rebar without guaranteeing collision-free rebar in the frame. In the case of this two-layer frame, the methodological framework proposed in this paper saves approximately 90% of the time compared to manual labor, and thus the methodological framework can provide efficient collision-free rebar design.

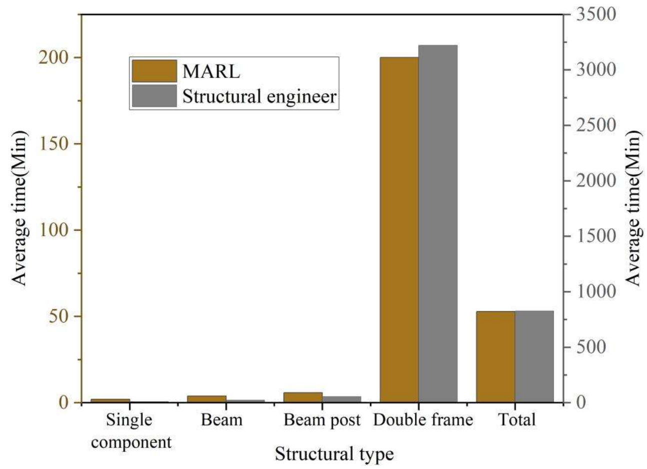

Fig. 4. Manual saving

4.3. *Construction Cost Management Optimization with BIM Technology Based on Multi-Intelligent Body System*

Before and after the optimization, respectively, extract the amount of installation materials to form a table, and make a comparison, and combined with the project's bill of quantities to analyze the project cost that can be saved by this item. This paper takes the drainage pipeline as an example to analyze the optimization that pipeline synthesis can bring to the project cost. Optimization before and after the amount of work according to the wastewater system, cold water supply, hot water supply, hot water back to the classification of the summary, and in turn with the optimization of the system before the amount of work minus the amount of optimization after the amount of work, the value will be filled into the table “before and after optimization of the difference between the value of the changes in the” one, so that the value of this item is a positive number represents that the pipeline synthesis can be If the value of this item is positive, it means that the combined pipeline at this place can save the amount of pipeline, and if the value is negative, it means that the amount of work after optimization has increased compared with the amount of work before optimization. As some pipelines need to adjust the elevation downward, or adjust the position of pipelines to avoid other pipelines, it is inevitable that the project volume of some pipelines will increase. The comparative results of the wastewater system are shown in Table 2, and it can be seen from the data that there are increases and decreases in the amount of pipeline work in the wastewater system, and the overall change is not significant. Among them, the amount of pipeline works of DN34 and DN104 are less than that before optimization, and the amount of pipeline works of DN78 and DN52 is increased compared with that before optimization, but the difference between the increased and decreased amount of works is less.

Table 2. Comparison of the total quantity of wastewater pipeline

Serial number	Optimize the specification of the former components /mm	Material	Quantity of engineering/ m	Optimize the specification of the former components /mm	Quantity of engineering /m	Difference value /mm
14.1	DN34	Cast iron tube	30.12	DN34	23.34	6.78
14.2	DN52	Cast iron tube	73.84	DN52	79.42	-5.58
14.3	DN78	Cast iron tube	80.23	DN78	84.67	-4.44
14.4	DN104	Cast iron tube	92.25	DN104	83.12	9.13

Cold water supply pipeline volume comparison shown in Table 3, from the data in the table can be seen after the optimization of the system pipeline volume compared to the optimization of the overall reduction, especially the DN68 thin-walled stainless steel pipe to reduce the volume of work is more, about 56m, followed by DN26 and DN34 pipeline in that order 22.69m and 6.35m, but DN20 pipeline than before the optimization of the increase of about 10.52m.

Table 3. Comparison of water pipeline engineering quantity in cold water

Serial number	Optimize the specification of the former components /mm	Material	Quantity of engineering/ m	Optimize the specification of the former components /mm	Quantity of engineering /m	Difference value /m
1.1	DN18	Thin-walled stainless steel tube	11.05	DN18	11.22	0.17
1.2	DN20	Thin-walled stainless steel tube	312.84	DN20	323.36	10.52
1.3	DN26	Thin-walled stainless steel tube	140.83	DN26	118.14	-22.69
1.4	DN34	Thin-walled stainless steel tube	19.32	DN34	12.97	-6.35
1.5	DN68	Thin-walled stainless steel tube	98	DN68	42	-56

According to the comparison table of the amount of work before and after the optimization of each system, the difference between before and after the optimization is applied to the list, and the overall cost of this optimization can be derived. Through the analysis, it can be seen that the engineering quantity of hot water supply system and cold water supply system changes a lot, so the hot water supply system and cold water supply system are discussed as examples. The difference in the amount of piping work before and after the optimization of the hot water supply system can be derived, and the difference is applied to the list as shown in Table 4, and for the convenience of display, the item characteristics of the list are not shown in this table. The amount of each item in the table is summarized, and based on the contract documents for fees and taxes, the total amount of optimization of hot water supply system can be summarized as 25402.93 yuan.

Table 4. Heat water return water pipe line to the ratio of the process

Serial number	Optimize the specification of the former components /mm	Material	Quantity of engineering/ m	Optimize the specification of the former components /mm	Quantity of engineering /m	Difference value /mm
1.1	DN22	Thin-walled stainless steel tube	118.49	DN22	122.96	4.47
1.2	DN28	Thin-walled stainless steel tube	11.58	DN28	6.25	-5.33
1.3	DN45	Thin-walled stainless steel tube	14.47	DN45	16	1.53
1.4	DN54	Thin-walled stainless steel tube	69.22	DN54	48	-21.22
1.5	DN66	Thin-walled stainless steel tube	9.89	DN66	16	6.11

In turn, the remaining two systems optimization of the piping differences generated by the application of the corresponding list, the results are shown in Table 5, it can be learned that the optimization of the wastewater system cost savings of 1068 yuan, the hot water back to the piping optimization of cost savings of 1364.63 yuan, combined with the remaining two systems can be known as the total amount of savings of about 26,767.56 yuan.

Table 5. Comparison of water pipeline engineering quantity in cold water

Order	Project coding	Name	Engineering quantity	Amount	
				Integrated unit price/yuan	Interest rate/yuan
1	031001003011	Stainless steel tube	-24.45	36.45	-891.2025
2	0310010003012	Stainless steel tube	13.97	55.17	770.7249
3	031001003013	Stainless steel tube	2.94	50.04	147.1176
4	031001003015	Stainless steel tube	52.24	129.25	6752.02
5	031001005006	Cast iron tube	131.18	146.72	19246.7296

According to the arrangement of the construction schedule, the work volume at the corresponding time nodes is extracted, and combined with the relevant cost information, the budgeted cost of its planned completion work is calculated, and the results are shown in Table 6.

Table 6. Planned budget

Sub-project	Time/week								
	1	2	3	4	5	6	7	8	9
Core cylinder concrete column, peripheral mixing	58.69								
column, beam,		67.52	70.34	71.58	67.52				
wall, stair						46.67	59.74	41.65	50.11
BCWS	58.69	118.21	188.55	260.13	327.65	374.32	434.06	475.71	525.82

Real-time tracking of the project construction progress, all the relevant project information, progress check time nodes before the recording of documents and other content updated, entered into the project BIM model, easy to obtain the actual cost of the completed project to calculate the relevant data required, the results of the calculations are shown in Table 7.

Table 7. Actual cost of completion

Sub-project	Time/week					
	1	2	3	4	5	6
Core cylinder concrete column, peripheral mixing	58.47					
column, beam,		64.45	67.64	67.31	60.93	0.68
wall, stair						50.04
ACWP	58.47	122.92	190.56	257.87	318.8	369.52

In fact, the project in the first phase of the project cost expenditure, there is the phenomenon of excess. Before the start of Phase II, the costs were reduced due to the use of BIM technology for multi-intelligence systems, effective control of cost forecasting beforehand, avoidance of undesirable problems during the process, and optimization of the cost components after the end of Phase II.

Within this sub-section, a comparative analysis of the project's cost reductions and reduction rates is presented. The results are shown in Table 8, with a total of 382,320,000 yuan in cost savings for the project.

Table 8. Analysis of cost comparison of project units

Order	Project	The cost of the first phase of the sale	The actual unit cost of the second phase	Low unit cost	Unit cost reduction	Cost savings (Ten thousand)
1	Civil engineering	0.3	0.194	0.014	2.83%	16.432
2	Installation engineering	11	9.74	0.20	0.96%	2.8
3	Cable engineering	0.2	0.099	0.003	1.00%	3
4	Overhead road engineering	53	46	6	6.06%	16
Total						38.232

5. Conclusion

This paper mainly proposes an intelligent calculation method for cost management based on multi-intelligence system and building information modeling BIM, which is verified by 40 independent simulations of rebar paths, and the average success rate of BIM and multi-intelligence body calculations reaches almost 100% as the number of iterations increases. In this paper, the ZZYH comprehensive business building is selected as the object of analysis for the construction cost management application of BIM technology with multi-intelligent body system. The method in this paper successfully realizes the design of building reinforcement alignment avoidance, and also saves about 90% of time compared to the manual design by structural engineers. Comparing before and after the implementation of this paper's method, the amount of pipeline engineering has increased and decreased, the overall change is not significant, civil engineering, installation engineering, cable engineering, overhead line engineering all aspects of the construction cost have different degrees of savings.

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