Energy-Saving Optimization of Water Supply Pumping Station Life Cycle Based on BIM Technology

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Abstract. In the urban water supply system, pump station is the main unit of energy consumption. In the background of pushing forward the informatization in China, using BIM technology in design, construction and operations of water supply pumping station, can break through the limitations of the traditional model and effectively achieve the goal of energy conservation and emissions reduction. This work researches the way to solve energy-saving optimization problems in the process of whole life cycle of water supply pumping station based on BIM technology, and put forward the feasible strategies of BIM application in order to realize the healthy and sustainable development goals by establishing the BIM model of water supply pumping station of Qingdao Guzhenkou water supply project.

1. The background and significance of the research

In the urban water supply system, pumping station is the main unit of energy consumption, its electricity consumption can reach 95% ~ 98% of the whole water supply system. The design purpose of pumping station is to save energy under the premise that meet the requirements of the quantity and hydraulic pressure. In recent years, with the increase of population and the expansion of water supply, the design, construction and operations of urban water supply pumping station are also faced with more complex problems. To realize energy conservation and emissions reduction of the pumping station, its design, construction and operation need to be optimized. The pumping station construction shuold meet the need of water supply and adapt to the new policy of sustainable development at the same time.

At present, a new generation of information technology represented by the Internet, mobile Internet, smart technology brings us the third information technology revolution. By combining information technology with urban infrastructure and city management operating system, the informatization development trend becomes intelligent, the traditional water sector is also experiencing a digital revolution, so the new idea Intelligent Water Affairs has emerged. BIM (Building Information Modeling) involves in the whole life cycle of buildings, contains a large number of material, structure, equipment and process information of the construction. Different from the traditional chart engineering model makes the attribute information and spatial information of components and equipment relatively isolated, and difficult to collect different professional information for effective simulation, BIM can establish model with attribute information. Based on the model of information integration, BIM can provide a unified and cooperative data management operation platform for the dynamic simulation, thus optimizes different stages of the project and provides strong support for exploration of energy conservation and emissions reduction. Using BIM technology can make design,

construction and operation maintenance process of pumping station project a continuous whole, realize the whole life cycle of the pumping station informatization, and establish enterprise information platform to fundamentally solve the problem of water enterprise information isolated. Using BIM technology can make design, construction and operation maintenance process of pumping station project a continuous whole, realize the whole life cycle of pumping station informatization, and establish enterprise information platform to fundamentally solve the problem of water enterprise information isolated. It helps water companies realize the informatization of production operations management and process optimization scheduling, provide a basic platform for the realization of the Intelligent Water Affairs, thus makes saving energy possible.

This design will apply BIM technology to the whole life cycle process of the secondary pumping station of Qingdao Guzhenkou water supply project. It optimizes the process from the initial design stage, and explores scientific pumping operation based on BIM to improve the efficiency of pumps, makes the devices work in a condition of low power consumption with meeting the requirement of the process.

2. The introduction of the project

This work takes the secondary pumping station from water supply project of Qingdao Guzhenkou military and civilian integrated demonstration area as the research object. This pumping station is located in Qingdao Jingang East Street, it is a semi-underground single-layer workshop with frame structure, its construction area is 297.92 m^2. The recent scale of the pumping station design is 20000 m^3/d, the long-term scale is 45000 m^3/d. The recent scale has four small flow pumps, three in use another standby, the long-term scale adds two large flow pumps, with one in use the other standby. The parameters of the small flow pump are Q=362 m^3/h, H=45 m, N=75 kw. The parameters of the large one are Q=1167 m^3/h, H=45 m, N=220 kw. This project involves many professional fields such as building construction, structure, water supply, water drainage and electricity, this paper mainly adopts BIM softwares to model building and simulation analysis for the pump station's building construction, structure, water supply and drainage parts.

3. The application of BIM in life cycle energy-saving optimization of water supply pumping station

This work uses Revit for 3D visualization design, setting up a 3D model which contains all the engineering information of the pumping station. By importing the model to Navisworks, Fuzor and Glodon for processing, completed collision check, special design for green construction, scheme comparison, construction progress simulation and statistics of quantities, a series of work in turn, to reduce the earth volume, saving construction materials, reduce the resource losses. And provide the pumps an information management system model foundation based on VR to work in a energy-saving condition. Figure 1 shows a preliminary model of the pumping station built by Revit.

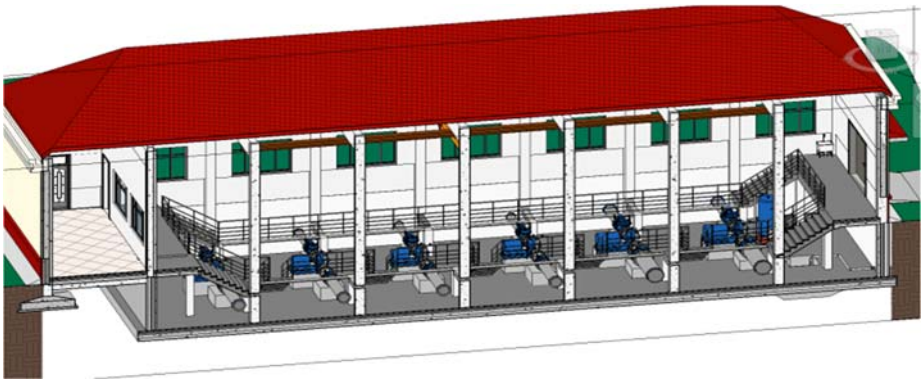

Figure 1. The preliminary model of the pumping station built by Revit

3.1. design stage

Using BIM technology in the pumping station project, makes analysis simulation possible in early design stage. By using its visualized characteristic to inspect the model or importing BIM models to analysis software to analyze in the early stage of design, according to the analysis result of the model to make change in time, which is beneficial to find and solve problems in early engineering, improve the design quality so as to minimize the unnecessary construction rework and waste of resources. In traditional 2D design, it is difficult to reflect intuitive positional relationship of components by drawing various of independent sectional drawing and plans, which leads a large number of collision problems in later construction and takes a lot of time and money to change the pipes or change the reserved hole position to avoid collisions. Once the project construction begins, the completed works are hard to edit again, the local rework will bring a lot of economic losses, cause an unnecessary waste of materials. BIM technology can effectively avoid this problem at the early stage of design, by using Revit to set up 3D model in a visual way in this project, we found some eccentric reducers' elevation and pumps' elevation suffer from shaft misalignment, and elevation of pump is above the pump base, as shown in figure 2. After comprehensive adjusting on the premise of meeting the pump's allowable suction vacuum value, we modified the elevation of inlet pipes and improve the bottom elevation of pumping station about 100 mm, reduced the earthwork quantity, and avoided the waste of resources caused by rework problems. Import the Revit model to Navisworks for collision inspections, generate the test reports, find out 87 collision problems, confirm 24 influential collision points and make a design change to adjust them, solve the hidden trouble of construction rework. Figure 3 shows using Navisworks to inspect the collisions between water pipes and box beams.

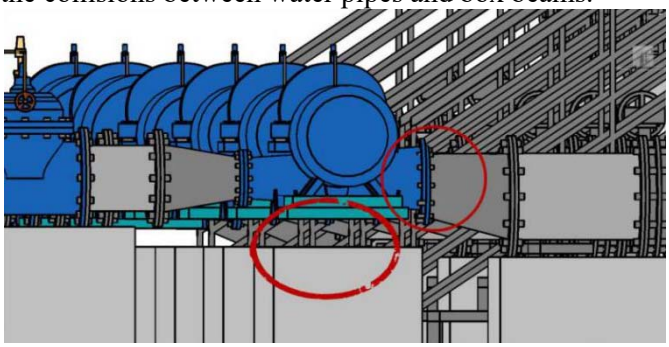

Figure 2. Pump elevation problems discovered by Revit 3D visual modeling

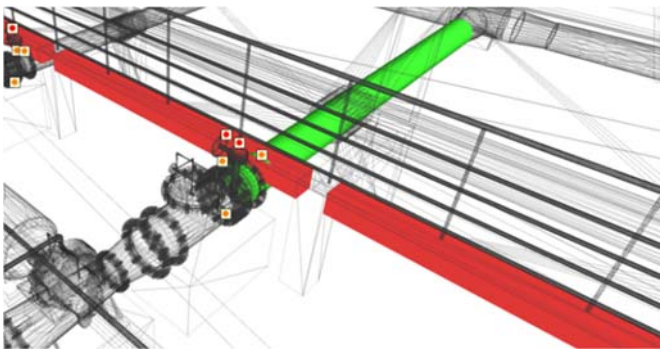

Figure 3. Collisions between water pipes and box beams

3.2. Stage of construction management

Traditional way of construction schedule management is using the medium of form, graphics and other paper documents, with the help of some softwares to complete the communication and coordination between various professionals. These methods can't directly display the progress plan or track the situation of the construction progress, and unable to accurately describe the construction site use, arrangement of the space and dynamic allocation of resources, which causes a large number of construction risk factors such as resource consumption, severe pollution, progress lags behind and the

engineering quality defects, these risk factors restrict the sustainable development of green construction. While BIM technology can solve the problem well.

Before the project construction, using Microsoft Project to establish green construction special plan for pumping station project, import multiple file of construction plan to Navisworks, after using timeliner function to dock schedule file and make every task associated with a corresponding model artifacts in the progress, 4D construction progress simulation will be carried on. Make use of BIM technology to achieve real-time interactive and realistic simulation, by analysing the dynamic project scene of simulation animation and time arrangement, finally through the comparison, determine the use of prefabricated construction technology.

In the process of construction, use Navisworks software can continue to optimize the construction of prefabricated assembly process, engineering data can be collected directly from the construction site, and manually input to the BIM model for actual schedule and plan schedule dynamic contrast demonstration.In this project, by inputting node task time to compare the project schedule and actual progress BIM growth model, can be clearly observed the contrast between growth process of this project and the actual schedule progress , master the rate of progress at any time. As shown in figure 4, the blue part of the model shows the task ahead of schedule, while the red part shows the delayed task. According to the comparison results, take timely corrective measures and modify the project schemes to guide the production and transportation of prefabricated components, control the progress, ensure the supply of prefabricated components and zero stack on construction site, which greatly reduced interference and eliminate the dust pollution, so as to achieve the goal of green construction.

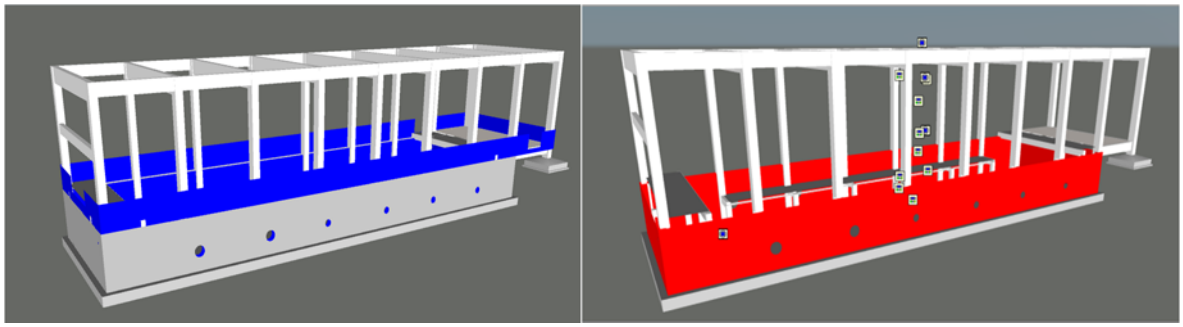

Figure 4. The comparison between actual construction progress and the plan

3.3. Quantity statistics and cost control

In traditional construction cost management, project cost personnel finish artificial statistics on the basis of a large number of 2D drawings, which need a lot of time to count and verify various number of table, so as to achieve the aim of artificial control of engineering cost. Taking use of BIM model, can achieve accurate calculation of quantity statistics and the budget cost, reduce man-made faults, so as to realize construction resources rational allocation and reduce materials waste caused by purchasing errors.

Revit has quantity calculation function, as long as accurately express in the information model, the number of quantities can be counted accurately. Statistical unit quantities such as area, volume and quality, requires the users set parameters in the modeling process, then it can be directly extracted in the statistics of quantities, form a separate schedule of material to guide the material purchasing, reduces the mistakes caused by human factors, which makes statistical results more accurate. This article uses Revit to automaticlly list detailed quantities of pumping station model.

After completed the statistics, export the bill of quantities to excel spreadsheet, extract the effective information, then import it to Glodon GBQ software, according to the market price information for the price adjustment, finally obtain the project cost information. In this way, it is unnecessary to import items artificially, reduces the mitakes caused by human factors and makes the calculation results more accurate. This kind of cost control based on BIM technology assists project managers quickly get the

budget cost of each construction period, and make a more scientific decision-making in subcontract cost control, thereby significantly increased the level of elaborating management.

3.4. Exploration in operation and maintenance stage

The key link to save energe in pumping station operation and maintenance is to grasp the relevant information of the pump equipments and match pumps reasonablely. We need to combine with the actual situation in the operation process to deploy the pumps, with the scientific operation between various pumps to avoid the problem that single equipment overload with high energy consumption. Now, the pumping station equipments management is still in the phase of parameter type management, equipment information are mostly in the form of words or charts for storing and displaying, thus lead to the equipment information isolated and hard for workers to get the relationship between attribute information and spatial information directly, which causes a low efficiency in equipment maintenance and operation management.

BIM technology provides a good idea to solve this problem. As a plug-in of Revit, there is no gap between Fuzor and Revit, it doesn't need a cumbersome file conversion, just click Launch Fuzor in Revit, model information real-time synchronization can be realized in the two-way of the two software. Fuzor can not only provide managers with a high immersion real-time interactive VR roaming scene, as shown in figure 5, it can also add annotations information to the object in the process of roaming, by using collaborative serve function, all the information of the project can be involved in private or public clouds, makes it possible for managers to query and manage equipment information in 3D scene. Fuzor can also support mobile client, it allows BIM model which is larger than 5G smoothly display in mobile devices, free to browse, mark messages, measure and check the BIM model parameters, call up the information at any time to manage equipment information, this intuitive interactions makes the equipment management of pumping station more efficient.

Figure 5. Roaming management interface of Fuzor

By docking 2D device management software to summary and store the statistical information, forming all kinds of pumps production reports, we can according to the working condition of pumps to explore the optimal combination equipments, which provides a strong support to achieve energy-saving optimization in pumping station operation and maintenance stage. Based on the interactive VR platform provided by Fuzor, access the BIM model to the SCADA system for pumping station real-time data, VR display function can integrate simulation animation and live video to display to the users, the users can be clear to the equipments condition in front of the computer. It can be used for pumping station operation real-time monitoring, by real-time processing the data and forming the scientific operation scheme, senting commands to control institutions to control the pumps, scientific scheduling and energy-saving operation can be realized.

4. The innovation points and application prospects

4.1. The innovation points

Energy saving is the primary task of the pumping station design and operation, using BIM technology at each stage of the whole life cycle of the pumping station can make the engineering design, construction operation and maintenance process information form a continuous whole, integrate them in an only one model for different participants to extract and input information. By using the completed information of construction, engineering and equipment contains in the BIM model reasonablely, we can reduce consumption and effectively improve the efficiency of management at the same time.

Using BIM technology in pumping station engineering can fundamentally change the way of creating building information. Digital building information model is created since the pumping station initial design stage, it changes the way of information management and sharing in traditional engineering, enhances the enterprise informationization management level, provides the basis for Intelligent Water Affairs.

4.2. The application prospects

BIM technology has gradually been accepted in domestic, and has been applied in some large engineering projects, the related software products also become more mature and indigenized in the whole process. In the background of vigorously promoting informationization, our country has increased the promotion strength of BIM technology in the Eleventh Five-year Plan, which requires to research and develop the use of BIM technology in architecture design, energy-saving design, construction optimization, construction safety analysis and cost estimation, in order to realize the efficient use of the BIM model and achieve scientific management. So apply BIM technology to the optimization of water supply pumping station life cycle can provide the basis to promote Intelligent Water Affairs and realize the optimization of energy-saving, meet the need of policy trends at the same time, which is worth application and promotion.

Pumping station is the hub of the whole water supply system, it is also the main part of energy dissipation in the system. With the increase of population and the expansion of water supply, the energy consumption of urban water supply pumping station will continue to increase. Under the background of sustainable development, water supply pumping station needs to be optimized on each link, while BIM technology can provide us with a new train of thought, which is worth to popularize.

References

[1] Yang yu, Yin Hang. U.S. Green BIM Application Situation and Its Influence on Chinese Construction Field[J]. Engineering Sciences, 2011(08):103-112.
[2] Yang Qilin. Applied Reasearch on BIM-Based Collaborative Visualization Design[D]. Southwest Jiaotong University, 2016.
[3] Yu Longfei, Zhang Jiachun. Computer Integrated Construction System Based on BIM[J]. Journal of Civil Engineering and Management, 2015(04):73-78.
[4] Zhang chao. Research on Key Technology of Design and Construction of Precast Concrete Structure[D]. Southeast University, 2016.
[5] Xi Jialin. Exploring on Energy-saving Design of Office Building in Chongqing District Based on BIM Technology [D]. Chongqing University, 2013.
[6] Liu Jing. Design and Implementation of Rainwater Pumping Station Visual Equipment Management System Based on VR[D]. Hebei University of Engineering, 2015.
[7] Guo Yunpeng. Research on the Bim Technology Strategy in the Whole Life Cycle of Green Building[D]. Harbin Institute of Technology, 2013.
[8] Yu Guang. Analysis of Construction of Secondary Water Supply Pumping Station[J]. Technology Innovation and Application , 2011(23):169.
[9] Zhou Yan. Application of BIM 5D Technology in the Green Construction Risk Management[J]. Journal of Inner Mongolia University, 2016(07):440-447
[10] Sun Yuchen, Chen Qingyuan, Zhou Jiangxiang. The Application of Fuzor Simulation

Technology in Construction Projects[J]. Intelligent Building & Smart City, 2016(11):73-75.