Deepening of Integrated pipeline - based BIM

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Abstract. The traditional electromechanical design using two-dimensional drawings conveys information that is relatively abstract, which means simple profiles and elevation drawings can’t reflect the three-dimensional effect of the pipeline. And that will cause some problems such as collisions during the construction process, disordered pipeline layout, and unreasonable space utilization. As a three-dimensional design technology, BIM can solve the above problems well. This paper describes the deepening and construction methods of pipeline comprehensive based on BIM technology in detail. On the basis of refined modeling, combined with on-site construction experience and the comprehensive layout specifications of various professional pipelines, NAVISWORKS is used for collision detection, which is carried out with the designer and the builder, and the optimization of the original design drawings of the project. The deepened model can be used directly to guide on-site construction, that can reflect the important application value of BIM technology in electromechanical engineering.

1. Introduction

With the development and promotion of BIM technology, it plays an increasingly important role in construction engineering[1]. It shifts the focus of Party A from the problems of design drawings and construction units to the data integration of design parties, construction parties, suppliers and operators. The traditional two-dimensional drawings can’t reflect the three-dimensional effect, and the unfavorable points and collision points between the professional pipelines can’t be found in time and accurately. If the project hasn’t been deepened, the construction unit directly according to the original design drawings construction, different installation teams according to their respective construction experience to solve the collision problem, lack of overall consideration, that will lead to the installation of later support and hanger problems, that will also affect the duration of the project and increase the cost of manpower and material resources[2]. BIM technology optimizes the design drawings, on the premise of minimizing turn-over and ensuring clear height, considering the aesthetics of basement and feasibility of construction, the problem of pipeline collision will be solved, that can’t only improve the engineering design quality, but also improve the construction efficiency and engineering quality.

2. The importance of BIM technology

2.1. The core value of BIM electromechanical engineering optimization

BIM electromechanical optimization is to establish a visual three-dimensional model, sort out and review all design blueprints in the early stage of construction, find out drawing design problems and
disadvantages in advance and solve them in time. In the process of deepening, each functional area is reviewed, considering the economic, practical, beautiful, feasible, normative and other conditions, maximizing the net height of the basement, making all kinds of mechanical and electrical pipelines arranged in an orderly manner, and improving the owner's awareness of use. The completed model can also assist the construction, so that the site workers can understand the pipeline installation direction and complex node installation situation.

2.2. Electromechanical optimization workflow

2.2.1. Modeling basis. Modeling basis including design drawings of building, structure, water supply and drainage, electrical, heating and ventilation provided by Party A/Design Institute.

2.2.2. Work content and workflow. The deepening of BIM comprehensive management is to combine the experience of electromechanical installation and construction, the conditions of the construction site and the principles of electromechanical installation, to optimize the BIM electromechanical model reasonably, to achieve standardization, coordination, and beautiful appearance, and finally to implement on the ground, and to guide the construction on site. Main work flow of electromechanical deepening: Obtaining construction drawings from Party A/designer, reviewing drawings, planning construction model, drawing building model and electromechanical model, discovering problems during modeling, and submitting problem report. Secondly, the net height analysis of the whole building, the optimization of parking spaces, the design coordination meeting to review the drawings and models. The designer optimizes the design blueprint for the problem report and conducts preliminary deepening design. After the design optimization is completed, ensure that the BIM results can be used as a construction reference, and make a detailed explanation with the construction party, further review the comprehensive design results of the comprehensive management, and confirm that the drawings are correct and deliver the results.

3. Model establishment and optimization analysis

3.1. Principle of electromechanical optimization

Underground garage: The basement pipelines are arranged in the parking space area as far as possible, and the pipelines are concentrated over the rear of the parking space to maintain the overall perception of the basement. As far as possible don’t arrange the pipeline above the carriageway, leaving enough space for the carriageway. As far as possible integrated pipeline installation, the same professional and functional pipeline as far as possible adjacent installation. If the pipeline meets the wind pipe, the pipe must be turned up, and must bypass the fire shutter door. Garage spray all open up three-way treatment, they should be arranged in the bottom of the secondary beam, spray supervisor as far as possible to stick the edge. Pay special attention to the layout of the exhaust outlet, to avoid the installation of pipes or pipe accessories and other obstructions in front of the exhaust outlet.

Main building part: The pipelines are all concentrated on the passageways and should be arranged in rows as far as possible. If the width of the walkway can’t meet the level of the pipeline, or there are two layers and three layers of pipeline, the pipeline all go through the comprehensive support, the construction should pay attention to the pipeline installation sequence. The pipeline of the elevator hall should be arranged as high as possible, for the late fine decoration reserved sufficient space. Due to the frequent maintenance lines, there should be sufficient space for the maintenance of weak bridge. Air duct should be arranged to observe the tuyere orientation. High voltage bridge and weak current bridge is more than 30 cm away to avoid electromagnetic interference. Due to the large difference of support type selection, it is suggested that air conditioning water and thermal pipeline should be arranged separately.
3.2. Notes for drawing building information model
- The single-storey building area of more than 50,000 square meters needs to be divided and built to avoid computer lag and affect efficiency.
- A single professional model is suggested to be done by a single person.
- Ensure the integrity of the model.
- Model accuracy requires reference to model accuracy standards.
- The base map of the modeling process should be placed in a professional file for easy inquiry.
- Any model must have a fixed axial network to prevent reference shifting and model management confusion.

![Figure 1](image1.png)

Figure 1. The civil model and electromechanical model of 1th underground before deepening

3.3. Analyze clearance height
With BIM technology simulation building process, it can be accurate show clear height of each functional area, according to each area clear height requirement and pipeline arrangement clear height analysis, discovered points that can't meet the demand of headroom requirement and beautiful place, to put forward rectification opinions by the designer, to avoid late construction because of lack of clear height of pipeline installation problems. The key points of analyzing are shown as follows.
- Whether the ramp meets the requirements of net height, whether it affects the vehicle access.
- Whether the pump room, pipe gallery, machine room and other densely packed pipelines meet the high purity requirements.
- Whether the main passage and the front room of the elevator meet the net height requirements.
- Check the net height of the beam pipe within the opening range of the air defense door.
- Whether the lanes and parking Spaces meet the requirements of net height. The clearance height of the driveway in the warehouse shall not be lower than 2.20m. The clearance height of the parking space shall not be lower than 2.00m. [3]

![Figure 2](image2.png)

Figure 2. Analysis chart of net height of underground layer

3.4. Detect collisions between electrical and mechanical pipelines

3.4.1. Collision detection among different specialties. The information reflected in the two-dimensional drawings is limited, and the elevation differences can’t be explained, and the conflicts of each professional detail can’t be easily found. In the early stage of construction, the pipeline synthesis
and collision detection are carried out to each other, and the design modification is carried out in advance to reduce the change in the construction stage. Collision detection is mainly aimed at integrated pipeline, including internal detection of pipeline system, internal detection of HVAC system, internal detection of electrical system and detection between various specialties[4].

### 3.4.2. Check key points

- **Ramp:** whether the ramp meets the minimum net height requirement and whether it affects vehicle access.
- **Sump:** Sump should not be set behind the door or at the entrance of the ramp.[3] Focus on checking whether there is deviation in the location of sump in architectural, structural and electromechanical drawings.
- **Fire shutter:** whether the reserved space meets the requirements of installation and net height; Whether the electrical and mechanical pipeline across the curtain.
- **Stairs:** check the direction of the stairs and check whether the pipeline direction of the stairwell can be installed normally.
- **Civil air defense:** check whether the entrance of civil air defense door affects pipeline crossing, whether there are obstacles within the opening range, whether there will be encroachment of parking Spaces after opening, and whether live thresholds are adopted.
- **Pipe well:** check the correctness of pipe well position, and the pipe diameter position of each floor drawing must be consistent.
- **Machine room:** check whether it meets the maintenance space and arrangement space.
- **Reserved hole:** the location of reserved hole should avoid beams, columns, stairs, etc., so as not to affect the use function of the building. [5]

### 3.5. Problem reporting

The problem report is composed of text, 2D and 3D images, reflecting the problem in multiple dimensions.

![Problem Report Feedback Form](image)

**Figure 3.** Problem Report Feedback Form

### 3.6. Tracking

Check the completeness of drawings; Check the standardization of drawings; Check the drawing design standards; Check surface error, missing information, pipeline collision and other problems; Check the rationality of each system design; Check function and effect. For each verification content, relevant written problem reports shall be submitted to the construction party, the design institute and Party A in a timely manner, and the problem solving shall be tracked and fed back to Party A.

### 3.7. Effect and Contrast

Before: Heat pipes, smoke pipes, strong and weak electric Bridges and spray pipes are staggered.
After: The pipeline is arranged in a neat way to meet the clearance height and maintenance functions.

![Figure 4. Comparative analysis graphics before and after deepening](image)

3.8. Submit deliverables and models

Deliverables:
- Basic models of architecture, structure and electromechanica.(RVT, NWD)
- Problem report and collision report of architectural, structural and electromechanical drawings.(DOC)
- Headroom height analysis chart of key locations.(DWG, PDF)
- Comprehensive optimization model of electromechanical pipeline.(RVT, NWD)
- Virtual roaming.(AVI, MP4)

In the process of mechanical and electrical deepening, The BIM unit shall actively cooperate with the relevant work of mechanical and electrical consultants, scheme units, decoration design units, construction drawing design units and other participating construction units. Delivering relevant model documents to Party A and the construction unit. Reporting the project to Party A in terms of the relationship between models, the relationship between drawings and models, the guiding role of BIM results in the site construction, the key difficulties and disadvantages of the project. Technical support can be provided if necessary to enable each participant of the project to clarify the value, process, requirements and relevant tools of BIM construction.

4. Conclusion

Application of electromechanical construction BIM in field construction is described in this paper. With the progress and popularization of BIM technology, BIM technology will be widely used in the process of engineering implementation. BIM technology is actively used in the mechanical pipeline actively adopts BIM technology, focusing on the application of integrated conflict detection based on BIM, three-dimensional pipeline synthesis, clearance optimization, virtual construction. Especially in the key parts of the project, such as garage, machine room, public area, commerce and so on, we should give full play to the advantages of BIM technology. On the basis of pipeline collision detection and 3D optimization, the construction site layout and factory prefabrication are integrated into it.

5. References

[1] Zhen-Qing Y, Hong Z, Li-Li Z, et al. 2015 Architecture Technology. 2: 132-134.
[2] Zhiliang M, Shiyao C. 2018 Construction Technology. 6: 70-72.
[3] Liming G. 2010 Study on the Planning and Design of Urban Residential Parking.(Changan University) 24-25
[4] Yunpeng G. 2017 Development Opment Guide To Building Materials. 012: 150-151.
[5] Sheng-rui Z, Yong W. 2017 Building Energy & Environment. 2: 94-96.