The Application of Building Information Model Modelling (BIM) in Flyovers Construction

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Abstract. Building information modelling (BIM) existed in 2002. Since then, it has become a useful tool in the engineering industry, especially for flyovers due to its complex construction process. Traffic congestion is a huge problem that many major cities are facing. It will have a negative effect on the environment and the economy. So, flyovers are essential for a city to reduce traffic congestion due to their high capacity compared to normal roads, but they usually face several problems in their design and construction, such as challenges in geological exploration and the effects on surrounding citizens. In this paper, theoretical analysis is used for discuss whether application of BIM in flyover construction is beneficial, and the result is that it will be easier to construct flyovers and reduce construction periods by better coordinating different construction sectors through BIM.

Keywords: BIM, Flyover, Engineering Design, Traffic Engineering, Underground Pipe

1 Introduction

Building information modelling (BIM) is a data model that integrates all kinds of relevant information about construction projects based on 3-D digital technology. BIM is the digital expression of the entity and functional characteristics of engineering project facilities. A complete information model can connect data, processes and resources at different stages of a construction project's life cycle. It is a complete description of the engineering object and can be widely used by all parties involved in the construction project [1]. Its operation principle is based on the actual construction situation of the construction project through the establishment of the 3D model and the integration of digital technology, in order to provide the model with the actual and complete engineering information base [2]. Flyover construction usually has a compacted construction period and complicated construction site, it contained transportation engineering, drainage engineering and structural engineering etc. So, the application of BIM can largely improve the time management and design of construction. Application of BIM technology in the construction project can also enhance the engineering information integration rate largely, by integrating constructing information model, data processing, and the design for project stakeholders such as personnel, operational companies and

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construction enterprises to provide a set of construction engineering project has centred on various aspects of information exchange and data sharing platform, at the same time, the application of these data information in the whole construction process of the construction project establish a data foundation for the later project planning, operation and maintenance and adjustment [2]. So, it is very essential to look forward to generalising and fulfilling BIM in the construction and design of flyover construction. In this dissertation, theoretical analysis and case studies are used to discuss effectiveness and usefulness of BIM in flyover construction.

2 The characteristic of BIM

The idea of building information modelling originated in the 1960s 'computer-based architecture drawing' put forward by Eastman. Compared to traditional graphic drawing, the computer-based one is easier to update and edit. Moreover, it enables us to observe spatial conflicts directly [3]. Through collision inspection, the rework and change caused by the collision between structures are reduced and the construction efficiency is improved [4]. The core idea of BIM is its harmony. The construction of urban rail transit consists of structure, communication, architecture etc. and there will be conflict in the construction of these areas during the construction. At the design stage, it is possible to establish all professional components, 3D models of the equipment and integrate the data from different professions into one by BIM. Then it would be easier to find the potential conflict for different areas in order to make changes immediately and reduce the delay of construction period to ensure quality of the project.

3 The characteristic of flyover construction

Traffic congestion is a huge problem which almost all major cities are experiencing with an increasing number of private cars, and it is more likely to happen in intersections. So, it is essential to construct flyovers in order to reduce the negative effects brought on by traffic congestion. Due to different urban planning and architecture styles, all cities with flyovers are unique, and it is relatively difficult to reference other examples. The construction site for the flyover is complicated. For example, there are underground or pipes below, and it increases the difficulty for piling and flyovers which are usually constructed above arterial roads; and it should not have an effect on the city's traffic. The design of the flyover needed to be according to local urban planning state and then have a field visit to inspect the geological condition, distribution of underground pipelines and the surrounding buildings' height. Usually, it involves several different majors, such as road engineering, bridge engineering, traffic engineering, sewage engineering and utility tunnel engineering. Moreover, there are many circumjacent environments restricts factors in the city centre which lead to a low efficiency and high challenge for traditional 2-D design [5].

4 The application of BIM in design phase

4.1 Yin Deng flyover project

4.1.1. Background.

Yin Deng flyover project of Nanning Wu Yu Airport second highway is located in the south-west part of the city. The project consists of a 1.183km long Yu Dong expressway with double ways and 8 lanes, Yin Hai expressway with double ways and lanes which has a length of 1.115km and two joint sectors of two arterial traffic roads.

4.1.2. Difficult in the project.

Yin Deng Flyover has muti-function, large-scale, complexed construction, complicated underground pipeline conditions and a wide range of related subjects. Most problems appeared in the flyover's piling for the reason that it is relatively near underground, so how to control the effect on the underground became a challenge for this project.

Fig. 1. Underground situation modelling

4.1.3. Application of BIM in the project.

The whole project was designed using the method of 2-D design and 3-D modelling by BIM technology created by Hong Ye software. The road, box girder, pier, and underground pipe network of the project was modelled by BIM and then using Navisworks, and Rhinoceros to refine, comprehensively analyse, and coordinate the application of the model.

Fig. 2. Final model of flyover

4.1.4. Effectiveness of BIM in the project.

Before BIM existed, CAD was used in municipal engineering design. However, in the 2-D design platform, some design ideas, purpose and final effects are difficult to represent in the blueprint, and if there are problems in the construction phase, experience is required to solve them. Via topography and geomorphology, geophysical data to have early-stage modelling in this project, and utilise BIM to focus on modelling flyover route, conjunction, pavement, bridge pier and pile foundation in order to accurately and quickly finds the 3-D model and provide the basis for design of flyover. Furthermore, BIM can prove the flyover design with evidence in order to give correct expression to the design intention. For example, there is an underground and it has some influence on the piling. By utilizing spatial analysis and collision detection, some potential problems can be avoided. In the project, the pipe gallery has conflicted with the flyover pier and drainage pipe. BIM has adjusted and improved the scheme immediately. This can reduce service later and enhance communication between different departments to bring convinces to whole project.

4.1.5. Work amount estimation.

In most cases, earthwork and road surface amounts can have small errors for those flat roads. However, errors can be massive if the topographic relief is massive and the road is not so flat. Flyover pilings contain complicated structures that can lead to omission when calculating. In this project, BIM is used to calculating parameter of the model and estimate work amount automatically and accurately. For example, the rebar needed based on BIM calculation was 672.4t, which is 27.8t less than the traditional calculating method. Meanwhile, it improved work efficiency of designers.

4.1.6. Muti-professional and collaborative design.

Through the BIM 3-D design of the project, the professional models of roads, bridges, drainage, traffic, landscape, underground structures, and other models are integrated into the same modelling platform, establishing a unified multi-professional collaborative design platform, which is also a highlight of the project. The establishment of a collaborative design platform is not just a simple model integration, it is also the transition of information and the project information exchange platform. The existence of this platform not only makes the project design professional communication and collaboration between each department more convenient, saving time cost, but also strengthens the regional scale efficient joint between different project design unit, reducing the conflict between the design. This ensures the coordinated advancement of the overall project [6].

4.2 Shuang Yuan and Shuang Ji road flyover project

4.2.1. Background.

Shuang Yuan Road and Shuang Ji Road are the starting points of the municipal expressway in south end. It is portal of the east downtown area of Qingdao, and it connect the east downtown to the airport and north downtown. The project uses the design of a double cross line and a directional ramp and it covers an area of 16 times 104 square metres. There are several challenges in this project. Firstly, in the planning phase, on the basis of connecting north and south, the project has to reserve the construction conditions for the future expressway in Shuang Yuan Road. Secondly, the construction site of the project is near the airport, so that drones cannot be used to sense terrain and modelling. Thirdly, there are dense firms and communities nearby, and there is a complicated underground utility below.

4.2.2. Design of the flyover on the basis of BIM.

The project is based on Hong Cheng integration platform, all design can directly entre the storage in order to curry out collaborate design work by BIM.

4.2.2.1. Realistic modelling and 3-D terrain analysis.

Since the drone is not available for detection, the project used GEO5 software based on traditional geological explosion resources to increase precision and security of design and provide flyover modelling with vicious geological explosion resource The BIM was used to create a virtual compound and ensure the scale and location of the flyover is identical to the real one.

4.2.2.2. More reliable scheme selection.

BIM technology enables engineers to use 3-D visualisation models to systematically display the relationship between the flyover and its connected road network, the surrounding environment and underground pipelines based on the comparison of conventional interchange functions, engineering investment and occupation scale. So, the selection of the scheme is more scientific and reasonable through BIM.

4.2.2.3. Traffic test.

By integrating traffic simulation software VISSIM with BIM, the traffic management department can simulate the conditions for intersection sets for north-south, east-west, south-west flyovers in order to optimise the connection between traffic signals between flyover and arterial traffic road below. BIM can also test virtually the driving on flyover, display traffic operation effects directly in order to optimise vertical and horizontal road combination design and improve safety and comfort of flyover driving. The combination of VISSIM and BIM can provide the basis and references to better manage the traffic on the flyover.

4.2.2.4. Pipeline design through BIM.

Data transmission between professional pipelines is realized through BIM, and pipeline collision situations are quickly checked by 3D visual sector in order to collaborate on the design of muti-professional for pipelines and effectively optimise layout of them. The change in range and quantity of the pipelines can be determined reasonably by using the example provided by BIM. The position relationship between pipeline status and pier distance can be reflected intuitively.

4.2.3. Construction of the flyover on the basis of BIM.

4.2.3.1. Collaboration and checking through BIM.

Through the integration platform of Hong Cheng, the BIM results of all majors are combined to achieve efficient communication of upstream and downstream professional data. On the basis of collaborative design, the BIM model results of all majors of the project are reviewed jointly and checked. Through the collaborative design integration platform, all professional responsible and audit personnel can view all professional design results systematically and administratively and manage each other, which improves the quality of results and design efficiency.

4.2.3.2. systematically analysis-collaboration-graphing through BIM.

Based on the 3-D geological data model, the refined 3D analysis and calculation check of the flyover foundation are carried out to ensure the safety and rationality of the substructure design.

By creating the model of the typical bridge space whole steel bar and prestressed steel beam, the space layout of steel bar and steel beam is presented Optimize and adjust, solve the "space interference of steel beam" problem in this prestressed bridge structure design difficulty, ensure the design and construction quality; Based on BIM parameterized model-calculation model-analysis results, realize one-key drawing and engineering quantity statistics

4.2.3.3. Road parameter testing through BIM.

Based on the road engineering design functions of Lu li De professional, such as horizontal and vertical, ultra-high and widening, the road BIM parametric model is created and positively combined with the design process to intuitively display the professional design of route combinations, ultra-high and widening, and optimize the design

parameters according to the requirements of national standards and visual effects. Combined with the geological model, the roadbed treatment scheme, scope, and depth under different geological conditions can be visually displayed and effectively reviewed. Based on the parameters of section and pavement structure layer determined in the BIM model, it is convenient for engineering quantity control of main building materials Meter; the BIM model based on the forward design of professional software can realize the rapid, mass drawing, and even direct delivery of construction and construction units to guide the site construction.

4.2.3.4. 3D visual blueprint.

BIM can show the result of design in a perceptual intuition and clear way to ensure the quality and efficiency of the construction [7].

5 Challenges faced through generalise of BIM

Although BIM is a useful tool in flyover construction, there are many challenges. First of all, the investment in it is not enough so that there is not enough talent to research on BIM. The result of this is the development of BIM is relatively slow. Second, there are significant polarisation, BIM technology is mature in the areas with developed economies and high level of investment. The use of BIM is most prevalent in firms with a complete industrial chain, which typically has more results, experience, and a complete lifecycle than firms with a relatively monotonous industrial chain [3]. The application of BIM technology is still in the exploratory stage of enlightenment, which requires software enterprises to focus on the localization of BIM technology and design enterprises to change their one-sided understanding of BIM technology [8]. The real value of BIM technology is reflected in the construction, operation and maintenance stage, but at present, in addition to the needs of owners, no other factors can become the driving force to promote the excellence of municipal engineering design [9]. Rather than hype up BIM, at the present stage, we should first seek truth from facts, hold a commonplace mentality, carefully and deeply understand it and continue to learn it. Finally, apply it pragmatically in the engineering project [10].

6 Conclusion

The existence of BIM largely changes traditional ways to design and construct flyover. It improves informatisation and more effective, promotes energy conservation and accelerates industrialisation in municipal engineering. This industry is now turning from 2-D to 3-D and has even contributed to smart city construction. However, there are still problems in utilizing BIM and more problems will emerge in the future. This dissertation mainly focused on flyover design and construction, and having limitations on the case is not enough. But there is more projects that can be used for municipal engineering with the development of BIM technology, and more practice and research should be done not only on the construction and design phase but also maintenance and traffic condition monitoring after construction and put into operation. The author hopes that

through continuous improvement and applications, with the development of BIM technology, it will be used more frequently and widely in municipal engineering and make a great contribution in the near future.

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