Application of BIM in Bridge Engineering and Its Risk Analysis

Yang Zheng1, Chunmei Xu1*

1Civil Engineering Institute, Southwest Forestry University, Kunming, Yunnan Province, 650224, China

*Corresponding author’s e-mail: 2219139473@qq.com

Abstract. Based on the BIM technology, the bridge information model and its related basic data are collected, so that the bridge project is applied to the entire project life cycle. This article explores the development characteristics of BIM technology in the bridge industry; combined with the current status of BIM in bridge engineering, it is found that it brings greater value in the design, construction, maintenance, and inspection stages; This article proposes and provides reasonable risk analysis and countermeasures on these aspects of technology and policy environment.

1. Introduction

BIM technology has gradually matured in engineering construction in various countries. By building a building information model to build an information framework system for the entire project, an engineering data model is finally formed to reduce engineering costs, achieve engineering visualization, information continuity and data integration the effect of management. This technology started late in China, so it is called a new era of technological innovation. Although China has made some research and exploration on BIM technology in recent years, it is still in its infancy, and its penetration rate is relatively low, especially insufficient teaching and application in bridge engineering, BIM technology has considerable value throughout the life of the project.

In terms of specific performance, in the design stage [1], through visual plan communication and visual design disclosure and construction simulation, the drawing efficiency and design efficiency are greatly improved, so that the project cost can be controlled and the effect of shortening the construction period can be controlled. And provide services for full life cycle management.

Based on the BIM technology, there are four benefits in the construction phase [2]. First, through the construction unit, construction unit, design unit, supervision unit and other parties to use BIM technology to enter project-related information, technicians can also call up the required information within their respective jurisdictions, synchronize, summarize and analyze the actual information to promote the realization of the management goals of all parties. The second point is that for some projects with greater emphasis and potential safety hazards, you can first use the BIM technology to perform relevant simulations, so that you can effectively identify and avoid risks in construction operations. The third point is to achieve comprehensive and effective project management goals by establishing control models at all stages of the construction process, and reasonably control and formulate more elaborate schedule and cost goals. The fourth point is to use the BIM information model to achieve the three-dimensional presentation of complex structures to achieve the design goal.
The application of bridge maintenance, based on the synchronization and revision of the BIM database, ensures that the bridge project is effectively organized and tracked during the maintenance phase, provides a visual display of the bridge model, avoids the error of the conclusion during the operation phase, and forms the software for the specific functions of the maintenance phase modules, such as management modules.

Maintenance management of BIM technology in bridge inspection, improve the detection efficiency of bridge parts with poor performance, find specific parts in the BIM model, find out the reasons and make a report, achieve the best maintenance plan, enter maintenance information after maintenance, for the replaced bridge parts or facilities are automatically recorded and updated in the model, and facility maintenance statistics and analysis are performed.

2. Application status of BIM technology in bridge engineering

2.1. design phase

In the bridge design stage, BIM technology is divided into scheme design, preliminary design and construction drawing design stage. Scheme design includes project initiation, scheme optimization, etc., that is, to establish a three-dimensional solid model with BIM software to visualize project information for reference and analysis by decision makers. The design documents for the specific construction, the depth of the plan design needs to meet the requirements for the preparation of the preliminary design documents and design estimates [3]: the preliminary design stage includes the overall design of the project; the construction drawing design is a further specific design for the project, the construction drawing design stage establish a visualization platform for the 3D solid model of the bridge to improve the communication and design efficiency of designers. For some complex and difficult bridge facilities or parts, it is easier to meet the design intent and improve the design efficiency. The BIM technology has the following application modules in the design stage, as shown in the figure1:

### Table 1. Application of BIM technology in Bridge design.

| Bridge type                  | Main application modules [4]                                                                 | Main software                  |
|-----------------------------|---------------------------------------------------------------------------------------------|--------------------------------|
| Steel bridge                | 3D modeling, information docking                                                            | Bentley, Tekla, Structures, CATIA |
| Cable-stayed bridge         | Complex modeling design, 2D drawing, engineering quantity statistics, collision check       | Revit, CATIA                  |
| Landscape bridge            | 3D modeling to detect problems with modification                                            | Solidworks, Revit              |
| Arch bridge                 | 3D modeling, 2D drawing, engineering quantity statistics, collision detection               | Revit, CATIA                  |
| Railway bridge              | Parametric modeling, structural simulation analysis, collision check, output construction drawings, material information endowment and project quantity statistics, guide construction process | CATIA, Solidworks, Bentley     |
| Highway Bridge Old Road Reconstruction | 3D parametric modeling, 2D drawing, engineering quantity statistics, collision check, 4D construction process simulation, data test interface in operation phase | CATIA, Solidworks, Bentley     |
| Simply supported beam bridge | Establish BIM model, construction rationality and conflict check, set drawing template, two-dimensional drawing, 4D construction process simulation, data test interface in operation stage | CATIA, Solidworks, Bentley     |

2.2. construction stage

The application in the construction stage is not yet mature and in-depth. For the bridge parts with complex construction technology, the construction process of the project is simulated by BIM...
technology to meet the effective identification and avoidance of risks in the construction operation and the realization of management goals. The application is shown in Figure 2:

Table 2. Application of BIM technology in bridge construction.

| Bridge type      | Main application module [4]                                                                 | Main software          |
|------------------|------------------------------------------------------------------------------------------|------------------------|
| Cable-stayed     | Visualized clarification, collision detection, construction material statistics, construction site layout, visualized construction management, in-depth design, calculation of engineering quantity, virtual construction | Navisworks, Revit      |
| arch bridge      | Construction model construction, 4D construction progress simulation, construction site management, collision detection, construction process simulation | Navisworks, Revit      |
| Suspension bridge| Construction simulation                                                                   | STBrIM                 |

2.3. Maintenance and testing phase

There are not many application cases of BIM technology in the maintenance phase. In the future, we are committed to shortening the inspection cycle, regularly maintaining, and combining with new technologies, connecting the information model with the structural analysis model, and testing and analyzing the stress analysis during the reinforcement and processing, building a database of bridge information files, to facilitate engineering personnel to call and share data at any time, thereby improving the level of key technology. Zhou Hongbo, Wang Zaijun [5] summarized the application of BIM technology in bridge operation and maintenance management: visual display of operation and maintenance process and results, convenient and intuitive; structured engineering data, establishment of complete bridge technology files; accurate maintenance workload statistics, conduct maintenance contract cost assessment, disaster emergency simulation, and optimize emergency plans. Wu Bin, Tan Zhuoying and others [6] summarized the intelligent management and maintenance function modules: maintenance plan reminder, 4D model display, structural performance evaluation, risk warning, maintenance plan optimization and auxiliary decision-making.

3. Risk analysis and countermeasures combining BIM technology

At present, there have been some achievements in the risk identification and management of bridge engineering, and we can actively carry out risk analysis based on human resources, process management, economy, technology, and policy environment.

3.1. Human Resources

As a new technology, BIM technology needs to solve many key technical problems, and the requirements for technical personnel will also be relatively increased, resulting in risks in terms of manpower:

• BIM technology as a new technology, for many people it is said that career planning is not clear and recognition is not high, so it lacks human resources.
• BIM technology needs to cooperate and bring a lot of risks to the rework of information users.
• The owner's knowledge structure is inadequate, and it cannot provide technical training for employees, and lacks third-party support.

In this regard, the following suggestions are made:

• The enterprise establishes a professional technical group, fully discusses and expresses opinions, conducts detailed discussions, and the results are reported by the person in charge.
• The enterprise strengthens the coordination of the responsible persons of all parties and formulates unified information management procedures to ensure the timeliness and synchronization of information transmission.
3.2. Process management

In the process of bridge construction management, there are the following risks [7]:

- Practitioners have the knowledge of BIM and the positioning risk of application goals.
- BIM technology has business transformation risks.

In the process management after the emergence of BIM technology, there are the following countermeasures:

- Technical personnel formulate emergency plans based on unexpected situations that occur during the process of BIM technology business transformation.
- Technical personnel widely consult relevant work and documents related to the application of BIM technology at home and abroad, and collect and organize them into data and reports for relevant technical personnel to consult.

3.3. Economic

In view of the current status of BIM technology application at home and abroad, in the long run, the economic benefits brought by the application of BIM technology are obvious, and its economic risks mainly exist in:

- the early return on investment is low, it is difficult to determine its development potential, so it A lot of financial support.
- It is difficult to determine the degree of acceptance and vitality in the market.

In order to enhance the advantages of BIM technology and reduce the economic risk of BIM technology application:

- The application of BIM technology can obtain policy support or enterprise investment.
- BIM technology establishes and improves the transformation mechanism of secondary development in the engineering field.

3.4. Technology

In the construction of bridge construction, the emergence of BIM technology will bring some technical risks:

- The uncertainty of the successful application of BIM technology is difficult to predict the funding gap caused by the expected effect.
- It is difficult to predict the substitution and sustainability of BIM technology.

The following countermeasures are recommended:

- The relevant person in charge needs to strengthen external cooperation and exchange, improve design and construction efficiency, and control costs.
- Developers should strengthen the research of BIM products and improve the adaptability of BIM products in the application of bridge engineering.

3.5. Policy Environment

BIM technology is in the exploration stage in China's policy environment. Whether it is the BIM technology application model or BIM related standards, most companies are still exploring. National level and local governments have issued relevant policies [8]: "2011-2015 construction industry informatization development outline" pointed out the popularization and application of BIM technology, promote the construction of informatization standards, and achieve the industrialization of BIM technology; "About soliciting recommendations on BIM The Guiding Opinions on the Application of Technology in the Construction Field (Consultation Draft) Opinion Letters until 2020, improve the BIM technology application standards and implementation guidelines, and form the BIM technology application standards and policy system; "Opinions" pointed out that promoting the application of BIM and other information technologies in the entire process of engineering design, construction, operation and maintenance, improving comprehensive benefits, popularizing seismic
isolation technology for construction projects, exploring the development of white drawings instead of blueprints, and digitally reviewing plans; The "Guiding Opinions on the Application of Building Information Models" puts forward clear objectives for the development of BIM in the next five years; the "Outline for the Development of Informatization in the Construction Industry 2016-2020" states that the level of informatization needs to be comprehensively improved.

The BIM technology is supported by the government and the country, so the risk of applying the policy to the bridge project is very small. To promote its development, the following suggestions are proposed:

- The state encourages the establishment of BIM technology in visual design, collaborative management, and virtual buildings, and sets specific standards for project goal management.
- The state encourages the introduction of relevant policies to support the integration of BIM technology with other new technologies, such as remote sensing.
- The state encourages the establishment of a complete bridge construction standard system and a unified national bridge construction management information platform.

4. Conclusion

The emergence of BIM technology has brought a driving force to improve design efficiency, control project costs and shorten the construction period through visual solutions in the design stage. In terms of construction, it is convenient to synchronize information, summarize and analyze and achieve the management objectives of all parties, and avoid construction risks. In terms of maintenance testing, the maintenance stage is effectively organized and tracked to ensure data consistency. The application in each stage is very wide, and some results have been achieved. In the human resources, process management, economy, technology, policy environment and other applications, the risks and countermeasures are analyzed.

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