Application Research on Information Integration Technology of Bridge BIM Model Based on 2-D EBS Coding System

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Abstract. In the trend of information technology, BIM Technology has been widely used in the design, construction and maintenance stages of bridge engineering activities with its own advantages. At present, BIM Technology has made further development to realize the bridge life cycle information. In view of the shortage of information carrier in the application of EBS in BIM life cycle, this paper proposes a 2-dimensional EBS coding system component decomposition coding system. The 2-D EBS coding system is composed of component information and subsidiary information. Through the practical application of Shapotou Yellow River Bridge in Ningxia, the possibility of 2-D EBS coding system in bridge life cycle information integration, exchange and storage is further verified. It provides a link role for bridge life cycle informatization, and has strong engineering practice significance.

1. Introduction
Although BIM Technology has been widely used in housing construction, it is seldom used in bridges. The slow application of BIM in highway bridges mainly includes two reasons. On the one hand, the standardization development of highway engineering construction field lags behind, on the other hand, the project scale is large and complex. In addition, the bridge components are more complex and there are many control variables in the construction process, which are also the difficulties in the application of BIM Technology in the whole life cycle. But as BIM brings great benefits to the construction field, the bridge field workers also began to study the bridge information construction. At present, BIM is widely used in developed countries. BIM Technology has been gradually used as an evaluation standard for the degree of engineering informatization. Nowadays, the academic community widely believes that BIM Technology is the best tool of bridge information. BIM plays an important role in the application and promotion of bridge informatization in China. The integration and application of bridge life cycle information must consider the design, construction, operation and maintenance stages. In order to standardize and unify information, the academic circles put forward to adopt EBS coding technology to solve this problem.

2. Engineering System Breakdown Structure (EBS)
BIM Technology is used to build bridge information model. From the perspective of the whole life cycle, due to the complexity of the information generated in each stage of the project activities, we need to use effective information management means to realize the application of BIM Technology in the whole life cycle of bridges. In the process of data integration and interaction of bridge BIM model, it is the
component of bridge data information base. EBS coding is the information carrier tool of BIM in the whole life cycle information of bridge engineering.

EBS (1-dimensional EBS coding system) is based on the functional decomposition of the engineering system. It decomposes the engineering system according to the functional surface and professional (functional) elements, and follows the principles and ideas from top to bottom and from the whole to the part, as shown in Figure 1. In order to integrate the structural information with BIM platform, it is necessary to encode the decomposed structural information with numbers.

![Figure 1. EBS breakdown tree.](image)

The process of bridge construction is characterized by large investment and many participating units. A large amount of complex engineering information involved in engineering activities. Different units participate in each stage, which determines that each participant needs to submit a large difference in information. However, the existing 1-dimensional EBS coding system does not describe the fineness of information sufficiently, which leads to the failure of the existing coding system to adapt to the different data coding requirements of the bridge at various stages, bringing many problems to the intelligent management of the bridge. The main reactions are as follows:

- (1) Information conflict and insufficient applicability.
- (2) The high repeatability of 1-D EBS coding.
- (3) The capacity of information carrier is insufficient.
- (4) Lack of time information description.

In the life cycle model of bridge based on EBS, time information should be recorded as well as updating the bridge information. 1-D EBS lacks time series in BIM model and only describes the data information generated by structural information. To adapt to the information integrity and uniqueness of the BIM model in the whole life cycle of the bridge.

3. Two dimensional EBS decomposition coding system

3.1. Information attributes of two-dimensional EBS

In view of the deficiency of 1-D EBS coding system in the bridge component library, the improvement is carried out under the condition of satisfying the information integration of the whole bridge life cycle. Based on the one-dimensional EBS coding system, the bridge component information and the bridge attribute information are reflected respectively. Compared with one-dimensional EBS coding system, the improved decomposed coding system has "two-dimensional" characteristics and can describe the detailed information more accurately. The most important characteristic of 2D EBS coding system is the combination of structural decomposition coding and information coding, as well as the uniqueness of component coding and the variability of information coding in bridge life cycle activities. To sum up, in order to meet the requirements of BIM model of bridge life cycle, this paper proposes that the structure of two-dimensional EBS coding system has the following characteristics:
(1) The 2-D EBS decomposition coding system consists of two parts, 2D EBS coding of bridge components and bridge accessory information.

(2) The 2-D EBS coding features are used to replace the one-dimensional EBS coding of bridge components. By referring to the coding rules of IFD and Omniclass system, the BIM technology can be applied and the segments of bridge components can be accurately positioned.

(3) The information in the 2-D EBS includes the location information, the engineering stage, the type of information and the time of information generation.

(4) The 2-D EBS code of the subsidiary information of bridge components is in the form of numbers and word abbreviations.

3.2. Two-dimensional EBS coding system

The 2-D EBS coding of bridge members. The 2-D EBS coding system is divided into two parts: 2-D EBS coding of bridge components and 2-D EBS coding of auxiliary information of bridge components. Based on one-dimensional EBS coding, a two-dimensional EBS coding for bridge components is proposed. In the decomposing and coding of bridge components, the one-dimensional EBS coding system is adopted, which consists of the decomposing diagram of bridge structure and the coding of bridge components. The two-dimensional EBS decomposition system is divided into six levels. Decomposition sequence should conform to the spatial structure characteristics of bridge engineering and follow the top-down principle. As shown in Figure 2, the arch bridge is decomposed according to the rules of the two-dimensional EBS coding system.

The 2-D EBS codes conform to the coding rules of Omniclass and IFD, and simplify the coding under the premise of satisfying the decomposition. For example, the first level code represents the bridge type: 01 is beam bridge, 02 is arch bridge, 03 is cable-stayed bridge, 04 is suspension bridge, 05 is other types of bridge. At the end of the coding information, the three digit coding is used for the positioning of bridge components. Considering that the bridge to the main girder decomposition may exceed the three-digit code, the three-digit code is adopted for the bridge segment positioning, as shown in Figure 3.
Bridge component information coding. The 2-D EBS code of bridge component information is divided into four levels, namely, the precise positioning information of the bridge component segment, the stage of the bridge information, the time and type of information generated.

The first layer is the detailed positioning of the bridge structural parts. For example, top represents the top plate, under represents the bottom plate, left represents the left web plate, and right represents the right web plate. The second layer of code represents the activity phase of the bridge, D (design) represents the design phase, C (construction) represents the construction phase, and O (operation) represents the operation and maintenance phase. The third layer of code means that the information is generated in "days". For example, on August 22, 2019, it is indicated as 190822. The fourth layer represents the type of additional information recorded, such as stress, elevation, etc. The specific rules are shown in Figure 4.

| 02(1st) | 01(2nd) | 00(3rd) | 03(4th) | 01(5th) | 001(6th) |
|---------|---------|---------|---------|---------|---------|
| 1st, indicating 02 arch bridge according to bridge type classification |
| 2nd represents the main bridge, and the main bridge approach represents 01 and 02 respectively |
| 3rd represents the integral type, and the integral type and the separated type are represented by 01, 02 and 03 respectively |
| 4th, which indicates the sequence decomposition of ancillary facilities, deck system, superstructure, substructure, etc |
| 5th layer, the arch ring, suspender and main beam representing the main arch ring are given in the order of the breakdown drawing |
| 6th represents the first segment of the left main arch, which is located by three digits |

Figure 3. 2-D EBS component coding
Figure 4. 2-D EBS component information coding

In the two-dimensional EBS coding system, in order to distinguish the component coding and the component accessory information coding, the continuous expression form of the previous coding characters is abandoned, and the symbols "," and ",-" are selected to distinguish the bridge component coding and the component accessory information coding, such as 02-01.00.03.01.001 and top-c-190116-st, which respectively represent the two-dimensional EBS component coding and the component accessory information coding of the arch bridge in Figure 3 and Figure 4. By changing the coding form, the EBS coding system is easier to read and identify. In order to distinguish part coding and part attachment information coding, the continuous expression of the previous encoding characters is abandoned. Select the "," and ",-" symbols to distinguish the bridge part code from the part attachment information code. For example, 02-01.00.03.01.001 and Top-C-190116-ST represent the 2D EBS component coding and component attachment information coding of the arch bridge in Fig.3 and Fig.4 respectively. By changing the encoding form, the 2-D EBS encoding system is easier to read and recognize.

3.3. The advantages of 2-D EBS

Compared with the one-dimensional EBS coding system, when the bridge BIM model component library is used as the information carrier, the two-dimensional EBS coding system has the following advantages:

- (1) The bridge as a whole system is based on the information generated during the whole life of the bridge components.
- (2) 2-D EBS coding system is adopted to fully consider the information that may need to be added to bridge components, so as to ensure the comprehensive adaptability of information carrier.
- (3) The coding system is composed of bridge structural component coding and component accessory information coding, which ensures the sufficiency of BIM model information.

- (4) The two-dimensional EBS code decomposition system can form a BIM model applicable to the whole life cycle, and feed back to design, construction and management. Collect information feedback from all parties in a timely manner.

- (5) The two-dimensional EBS coding solves the problem of inconsistent information carriers, avoids the complexity of BIM modeling caused by different coding systems, and is convenient for engineers to understand.

4. Application (Life cycle information model of Shapotou Yellow River Bridge)

Taking Shapotou Yellow River Bridge reinforcement project in Ningxia as an example, the feasibility of the coding system is verified. The main bridge of Ningxia Shapotou Yellow River Bridge. In order to ensure the safety of the bridge operation, the bridge reinforcement construction will be carried out in 2018. Two-dimensional EBS coding system is used to encode the information generated by the bridge, and the BIM model of the bridge is established.

Decomposition of bridge structure. When using the two-dimensional EBS coding system to decompose and code the bridge components, according to the decomposition principle, the box girder of the bridge is decomposed into the top plate, left web, right web and bottom plate in the transverse direction, and the box girder is decomposed from the small pile number to the large pile number in the longitudinal direction according to a section of 5m. The specific decomposition is shown in Fig. 5, and the bridge component coding is shown in Table 1.

![Figure 5. Stage coding diagram of main beam components](image-url)
Table 1. Two dimensional EBS code of main bridge components of Yellow River Bridge.

|   | Regulations on dividing sections of Yellow River Bridge Two dimensional EBS coding |
|---|---------------------------------------------------------------------------------|
| 1 | EBS component code of the top plate of the main girder section                   |
| 2 | EBS member code of left web of girder section                                    |
| 3 | EBS component code of girder segment bottom plate                                |
| 4 | EBS component code of girder diaphragm                                           |

Bridge component information coding. The 2-D EBS coding system of bridge component accessory information is carried out according to the above rules. The longitudinal positioning of bridge segments is coded according to the number of large piles to the number of small piles. Mainly used to locate the detailed information of the part.

The information coding of Shapotou Yellow River Bridge is mainly used to code the deflection information, stress information (including sensor section), crack information and health monitoring information of the main bridge after reinforcement. The above 2-D EBS coding system is used as the carrier of information interaction when building the bridge BIM model with Revit software. The BIM model of Yellow River Bridge is established by using the functional characteristics model of Revit family and parametric model. The information display of box girder section of Shapotou Bridge's whole life information BIM model is shown in Fig 6.

5. Conclusion

Through the above applications, it can be seen that the two-dimensional EBS coding system can better solve the problem of insufficient information carriers in the one-dimensional EBS coding system. The 2-D EBS coding system realizes the integration, interaction and storage of bridge information in all stages. To a certain extent, it solves the information island phenomenon.
Aiming at the problem that the technical information carriers of BIM technology application in the whole life cycle of bridge engineering are not unified, a two-dimensional EBS coding system based on one-dimensional EBS coding is proposed. Through the application of two-dimensional EBS coding system in Ningxia Shapotou Yellow River Bridge project, the feasibility of the two-dimensional EBS coding system integrating information in BIM model is verified. This method realizes the unified management of the whole life cycle information of the bridge, lays a foundation for the intelligent management of the bridge operation and maintenance, and has important practical reference significance for the systematic and intelligent management of bridge engineering.

References

[1] X. Gong, P. Michel, R. Cantin. Multiple-criteria decision analysis of BIM influences in building energy management[J]. Build. Simul., 2019, 12(4): 641-652.

[2] Gu N, Singh V, London K, et al. BIM: expectations and a reality check[J]. University of Newcastle, 2008:1-6.

[3] Qing H U. On the Application of BIM Technology in Bridge Engineering[J]. Value Engineering, 2015.

[4] National Insitute of Standards and Technology.[2009-4-13].http: //www.nist.gov.

[5] National Institute of Building Sciences. United States National Building Information Modeling Standard Version 1-Part1: Overview, Principles, and Methodologies[S/OL].[2009-4-13]. http: //www.wbdg.org/pdfs/NBIMsv 1-p1.pdf.

[6] General Administration of the United States General Services Administration (GAS) 3D-4D BIM Program http://www.gsa.gov/portal/category/21062.

[7] Song Zijing, Zhang Zheng, Xiang Wenfeng, et al. Research on Application of engineering system decomposition structure in super large bridge project management [J]. Construction economy, 2014 (8): 32-37.