On Calculation Scheme for List Engineering Quantity of Highway Engineering Based on BIM Model

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Abstract: This paper studies the ways to obtain the quantities of rebar, subgrade earthwork and other components in the field of highway engineering construction according to the relatively mature method of calculating quantities based on BIM model in the field of civil construction, and forms the calculation scheme for list engineering quantity of highway engineering based on BIM model that can be popularized and implemented.

Introduction

Engineering calculation is always the key and difficult point of the application of BIM technology. Domestic engineering quantity calculation software providers, such as Guanglianda, Luban, and Sville, have developed BIM quantity calculation software for civil construction projects, and have strong practicability. At the same time, the engineering quantity composition and the list pricing method of highway engineering are quite different from that of the housing construction project. At present, there is no mature BIM calculation software.

1. Research Background

Hefei-Zongyang Expressway is part of the “Three Verticals” in the “Five Verticals and Nine Crosses” in Anhui Expressway Planning Network. The total length of the route is 134 km. The route is a two-way four lane highway with a design speed of 120 km / h. There are many interchanges, super bridges and bridges, one tunnel, and a number of auxiliary buildings and other supporting facilities, and the approved budget is 10.459 billion RMB.

This project is a project for the application of BIM Technology. In order to improve the accuracy of project investment, technical research on extracting list engineering quantities from BIM model has been carried out, which provides a new implementation idea for list calculation of highway engineering based on BIM model.

2. Calculation Scheme for List Engineering Quantities "Full Materialization"

The core of BIM is to build a virtual three-dimensional model of construction engineering and use digital technology to provide a complete information base of construction engineering consistent with the actual situation. The information base contains not only the geometric information, professional attribute and state information of building components, but also the state information of non component objects, such as space and motion behavior.

2.1 Calculation Plan

According to the regulations on measurement rules in the “Bidding Engineering Standard Construction Bidding Documents” (2018 edition), the data required for the list engineering

quantities of highway engineering are the basic geometric information of the engineering entity such as the number, volume, weight, area and length, which can be calculated and generated by modeling software or other BIM software for related data statistics and calculations.

In theory, the data required for the list engineering quantities of highway engineering can be obtained from the BIM model. In the case where the relevant basic data is obtained, the combination of the list coding and the component process classification, the material classification, the specification classification or the above classification is performed, and the automatic generation of the list coding can be realized.

In order to facilitate the distinction, the author refers to the above method of calculating the list as the calculation scheme for list engineering quantity of “full materialization”.

By comparing the process classification, material classification, and specification classification information with the list engineering quantity, the list code of the bored pile can be automatically configured as 405-1-a-1 with the engineering quantity of 12m. The means by which the component is associated with the manifest is implemented by a customized information base, as shown in Table 1, Table 2.

Table 1 Example of pile foundation property of a bridge

member	Process classification	Material classification	Specification classification	length
1#Pile 3#pile	drilling piles	C30Underwater concrete	diameter1.2m	12m

Note: in BIM model, "process classification", "material classification" and "specification classification" are stored in coding form.

Table 2 Example of pile foundation of highway component library

Classification code	Component type	model	List code	Calculation rule description
030102	Pile foundation	Bored pile - onshore φ1200	405-1-a-1	Pile length

2.2 Disadvantages of Calculation Schemes for List Engineering Quantity of "Full Materialization"

The calculation scheme for list engineering quantity of “full materialization” is proposed based on the theory. In the actual operation process, there are some shortcomings, which are embodied in the following aspects:

2.2.1. The Current BIM Model does not have the Conditions to Build to the Part Level.

The calculation scheme for list engineering quantity of “full materialization” is based on the premise that the model achieves the accuracy of the part level. However, with current hardware and software conditions and manpower conditions, it is difficult to achieve part-level modeling of highway engineering, especially the modeling of rebar. The amount of list engineering quantity included in these part-level models is naturally not extracted.

2.2.2. It is Difficult to Establish Subgrade, Ancillary Works and Non-solid Models Accurately.

Subgrade engineering involves a large number of earthworks, and the treatment methods are complicated, such as digging steps, dredging, throwing stones, and geotextiles. The above engineering entities can not achieve refined modeling, and can not achieve the calculation scheme for list engineering quantity of “full materialization”.

In addition, the list engineering quantity of “full materialization” also contains some non-physical categories, such as "contractor resident construction", "toll system application software", "database system", and "work injury insurance", which can not obtain the relevant list engineering quantity through the model.

3. Calculation Plan for the List Engineering Quantity of "Template"

The calculation scheme for list engineering quantity of “full materialization” has all the above-mentioned deficiencies in the actual operation of the project. Through the research on the merger project, we propose a list engineering calculation scheme that is more in line with the characteristics of the highway engineering project and has more promotion value. The program is called the calculation scheme for list engineering quantity of “template”, which has the following characteristics:

(1) To replace the process classification, material classification, and specification classification with “type classification”, and establish a highway engineering component library based on the classification of highway engineering components.

Since the method of process classification, material classification, and specification classification cannot completely distinguish all road components, the merger project uses “model classification” as an alternative to the above three classifications, that is, whether it is a process difference, a material difference, or a specification, they are all distinguished by " type". The classification principle is similar to the “project characteristics” in municipal engineering.

Taking pile foundation as an example, the classification established by "type classification" is shown in Table 3.

Table 3 Example of type classification of pile foundation of a bridge

Component category	model	Model code
Pile foundation	Bored pile / φ1.0m/C30 underwater concrete / on land	a1
Pile foundation	Bored pile / φ1.2m / C30 underwater concrete / on land	a2
Pile foundation	Drive-in PRC/φ0.6m/C80	b1
Pile foundation	Drive-in PRC/φ0.8m/C80	b2

(2) To establish the mapping relationship of list coding based on the component library of highway engineering

As mentioned above, at this stage, it is difficult for the model to reach the part level. A BIM model may be a combination of multiple parts, so a model is also related to the quantities of multiple sub orders. Hefei-Zongyang project establishes the mapping relationship with the list code and builds the highway engineering component library. Taking pile foundation as an example, the link relationship between component library and list is shown in Table 4.

Table 4 Connection between pile foundation type and list of a bridge

Component category	model	List subheading	Measurement item
Pile foundation	Bored pile - φ1200 in water	405-1-b-1	Pile length
		403-1-a	Light round bar weight
		403-1-b	Ribbed steel bar weight
		405-4	Sound tube weight

Since the parts such as light-reinforced rebar, ribbed rebar, and acoustic measuring tubes are not reflected in the model, the part of the engineering quantity needs to be recorded in the form of “attributes”, which is entered by the designer during modeling.

(3) To submit non-geometric information in the form of "data template"

Considering that a large number of components such as highway engineering subgrade engineering cannot establish an accurate model and cannot obtain accurate engineering quantity information based on the model, the Hefei-Zongyang project adopts a “data template” method to transmit non-geometric information. The advantage of submitting non-geometric information with "data templates" is that designers can perform engineering calculations in the traditional way of working for some highway components that cannot be accurately modeled, and simply submit the model data in tabular format; for components such as Revit, the non-geometric information can be directly exported using the data export function of the modeling software.

Through the combing of the engineering quantity table in the existing construction drawing, the

Hefei-Zongang project has compiled 26 data templates for the subgrade project, and stipulates the field name, column number, data type and numerical requirements, as shown in Tables 5 and 6, and the example is shown in Table 7.

Table 5 List of data files of subgrade engineering in Hefei-Zongyang highway (part)

Table number	Table name
001-1	Subgrade drainage engineering quantity table - side ditch
001-2	Subgrade drainage design table - intercepting ditch
001-3	Subgrade drainage design table - seepage
001-4	Subgrade drainage design table - purification pool
001-5	Subgrade drainage design table - pipe jacking
002	Cultivated land before filling (pressure)
003	Dredging and drainage engineering quantity table
004-1	Bridge, Minghan back backfilling quantity table
004-2	Dark culvert backfill processing quantity table
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Table 6 001-1 Quantity of subgrade drainage engineering- side ditch header (part)

Field name	Column number	type of data	Numerical requirements	unit
Serial number	1	Long integer (Long)		--
region	2	text(text)		--
Starting point	3	Double precision floating point (Double)	Two decimal places	--
Section size - width	4	Double precision floating point (Double)	Three decimals	m
Cast-in-place C25 tong volume	5	Double precision floating point (Double)	Three decimals	m^3

Table 7 Quantity of subgrade drainage engineering (side ditch)

Serial number	region	Local space	length	Starting point	End point	model	Section size - width	Section size - high
			(m)				(m)	(m)
1	2	3	4	5	6	7	8	9
HZ-02	R340	0001	4128.00	K45+361.40	K48+204.40	Embankment Ditch - Type I-1	0.600	0.600
HZ-02	R350	0001	4388.20	K48+204.40	K50+950.00	Embankment Ditch - Type I-1	0.600	0.600

Slurry stone volume	Cast-in-place C25 tong volume	Prefabricated C30tong volume	Gravel cushion volume	Cement mortar volume	Water retaining soil volume	Excavation volume	Backfill volume	Reinforced HPB300 weight	Steel bar HRB400 weight
(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(kg)	(kg)
10	11	12	13	14	15	16	17	18	19
		738.912		495.360	743.040	3591.360			
		785.488		526.584	789.876	3817.734			
	29.120					42.980			

For non-physical construction projects and non-physical projects involved in the project, such as “software engineering” and “measurement fees”, Hefei-Zongyang highway also obtains non-geometric information in the form of data templates.

(4) List calculation process

After the list mapping table is established, the VBA automation processing program is developed, the data template is retrieved according to the data mark in the mapping table, and the data is counted to complete the list calculation.

4. Conclusion

The calculation method for list engineering quantity of "template", undertake the advantages of the calculation for the list engineering quantity of "full materialization", obtain the engineering quantity data through the non-geometric information in the BIM model, and also solve the problem of some engineering data sources that cannot be accurately modeled, and reduce the application difficulty of BIM technology. It provides a new idea for the application of BIM technology to the calculation for list engineering quantity of highway engineering.

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