Research on Simulation Technology of Highway Traffic Organization Based on BIM Technology

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Abstract: This paper mainly studies the joint application about BIM technique and three-dimensional (3-D) simulation of traffic organization. It is the first time to systematically break through the application bottleneck of BIM technology in traffic organization design and implementation of highway reconstruction and expansion project, which realize the vertical connection between BIM software and 3-D simulation of traffic organization data to the visual evaluation of traffic conditions by analyzing the visual electronic sand table. An interconnection between 3-D visual simulated data flow and Vissim transportation analysis data is also built up to highly restore the real traffic conditions under the implementation of traffic organization plan, which help us evaluate road capacity of diversion section, provide a guidance to design and implement the transportation proposal, and improve the efficiency of implementation.

1. Introduction
Since the concept of Building Information Model (BIM) was put forward, it has shown excellent process characteristics and high quality level in the project, which can not be ignored. The application of BIM technology in the field of highway engineering is slightly behind that in the field of construction. However, even though the application of BIM by most enterprises in the construction industry is limited to the simple application of 3-D model, such as collision inspection, in-depth inspection of construction drawings, automatic calculation of quantities, there are still some projects to practice 4D-BIM construction simulation and 5D-BIM schedule and cost control. Meanwhile, in the process of design and construction, especially in the construction of interchange reconstruction and expansion projects, we should not only give consideration to the normal traffic efficiency of existing projects, but also balance the progress of project construction in technical principle of normal traffic. Therefore, the difficulty is increased to reasonable planning of expressway traffic organization and transformation scheme.

3-D simulation of traffic organization can be an efficient means to break the traditional technical barriers for the realization of the overall construction goal of “good quality, low cost and high efficiency” to meet the information requirements of highway construction modernization. Through intuitional presentation about the movement of vehicles on a road network, 3-D simulation of traffic organization makes a scientific prediction on whether the traffic is congested and the road is unblocked at a certain location, so that corresponding traffic diversion measures can be put forward accordingly to optimize the traffic organization scheme in time and improve the traffic organization more scientific, operational and efficient. Combining the advantages of 3D information model with the requirements of traffic
efficiency and construction progress of old projects in highway reconstruction and expansion projects, the paper studies and establishes technical solutions for traffic organization simulation. It focuses on key control nodes which are prone to traffic organization conflicts, such as interchange reconstruction and expansion. By introducing the real traffic flow data, this study deeply analyzes the characteristics of vehicles, drivers and pedestrians, roads and traffic, visually shows the traffic situation of fore-and-aft implementation of the traffic organization scheme, which realizes the 3-D display of traffic flow, and reproduces its temporal and spatial changes.

2. Technology of 3-D traffic organization simulation

Technology of 3-D traffic organization simulation is used to visually guidance and optimization of traffic organization design and implementation by adopting BIM technology to conduct 3-D visual simulation of traffic organization scheme to realize the conversion of traffic organization scheme from 2-D plane to 3-D plane display. The traffic organization design simulation of the whole line traffic in the marked road section is established in advance according to the construction progress. Based on the analysis of the existing traffic flow data, we predict and analysis the carrying capacity of the traffic organization scheme on the traffic flow by traffic organization design and simulation in light of the poor traffic congestion at key guide exit. The feasibility and efficiency of the traffic organization scheme will be improved by optimizing the traffic guidance scheme in term of the simulation situation. In the process of implementation, the traffic organization plan shall be updated and adjusted to ensure that there is no interference between construction and traffic according to the adjustment of construction schedule and organization of traffic on site.

In the process of simulation, comprehensive consideration in geometric and the vehicle movement model help to reflect the impact of traffic control, bad weather, vehicle characteristics and other factors on the traffic simulation as true as possible, so as to establish a dynamic traffic organization model in line with the actual traffic conditions, and conduct statistical analysis on the traffic conditions. Large-area traffic flow simulation not only demonstrate the feasibility of the reconstruction and expansion scheme at the macro level, but also reflect the rationality of the diversion measures in a quick and intuitive way. Various traffic phenomena such as traffic organization simulate dynamic and realistic traffic flow, and traffic accident can reappears the temporal and spatial changes of traffic flow. Through in-depth analysis of the characteristics of vehicles, drivers and pedestrians, roads and traffic, we can conduct an effectively study on traffic planning, traffic organization and management, traffic energy saving and traffic flow rationalization. At the same time, through the direct performance of the vehicles’ movement in the road network, the traffic management department will make a scientific prediction of whether the traffic is congested and whether the road is unblocked. Moreover, the traffic diversion measures will be taken to give a guidance for vehicles in the upstream of the construction section and divert some traffic flow to other alternative routes, so as to ensure the smooth traffic of the construction section and avoid vehicle queuing.

The dynamic traffic system is described by means of numbers, words or graphics, and the evaluation report is issued to allow the construction party to better grasp and control the traffic conditions, which
reflect the rationality of the traffic organization scheme from the micro level to facilitate the communication among the project participants. In BIM simulation software, the 3-D simulation of traffic organization takes into account the corresponding construction plan, thus realizing the interference fusion of construction organization simulation and traffic organization simulation. Through the integration, we can assist in formulating the design scheme of overall construction organization with a determination of traffic restriction and rate-limiting scheme to reduce the traffic conflict rate of diversion and confluence and the possibility of traffic congestion.

Figure 2. Simulate Combination of Traffic and Construction Organization

Figure 3 Design Process of Traffic Organization Based on BIM Technology

3. Cross-Domain Integration Between BIM technology and Vissim
Get through the interconnection between simulation software of traffic organization and Vissim traffic analysis data. Meanwhile, the real traffic condition under the implementation of traffic organization scheme is highly restored, and the traffic capacity of the guided section is also automatically quantified
and analyzed with a correlation of the real traffic flow data of highway.

The highway route is established in the BIM modeling software and create the whole line BIM model in term of drawings. Among them, the precision of road, bridge and tunnel model must lower than lod100; By collecting the actual terrain information, the real terrain model can be created as much as possible in line with the current situation of the road. And the focus in the building of the BIM model is optimizing the direction and lane setting. In order to achieve the data interaction between BIM software and Vissim, the results of the model constructed by BIM modeling software must be imported into Vissim software in the file format of “INPX” to realize the real construction of the established route in Vissim. Meanwhile, the real traffic flow data and traffic organization scheme should be imported into Vissim for processing. And then make a quantitatively evaluate to the traffic capacity under the current traffic organization scheme, and carry out the corresponding traffic simulation analysis.

Finally, integrate the quantitative analysis data of Vissim’ traffic capacity and BIM model data of highway into LumenRT MicroStation software, which is served as the data support. In order to realize 3-D visual display of Vissim traffic analysis data and traffic flow conditions, the 3-D simulation of traffic organization should be established on the basis of existing highway BIM model with the integration of construction and traffic organization.

![Figure 4 Technical roadmap of integration of Vissim and BIM software](image1)

![Figure 5 Combination of BIM Software and Vissim Software](image2)
4. Engineering application

In the practical application of 3-D traffic organization with a cross-domain combination of BIM technology, we have successful realize the optimization of traffic organization scheme, and improve the scientificity, operability and efficiency of traffic organization.

(1) Old bridge widening

In view of the structure form of the old bridge is a concrete girder bridge with a span of 10m, and the new bridge is a $2 \times 13m$ prestressed concrete hollow slab bridge, so the expansion method adopted is to demolish the old bridge and build a new reaming and widening bridge. Based on the original construction plan, the original traffic organization scheme is divided into five stages to ensure the traffic of the original interchange channel. However, due to the complexity of local geology, such as cracks in the ground. So the construction of pile foundation becomes more difficult which affects the overall progress, and the actual construction progress has lagged far behind the schedule. In order to ensure the progress of the whole expressway to the left two-way traffic on time, it is decided to adjust the original construction scheme to the way of filling temporary subgrade to ensure the traffic on the left.

The visual 3-D simulation should be conducted in the design scheme of traffic organization of different stages in advance by integrating Vissim and BIM technology when adjust the traffic organization scheme. The traffic flow data of normal and peak periods in highway reconstruction and expansion phase are introduced to limit the speed of minibuses at 80km/h and that of large vehicles at 60km/h, and quantitatively evaluate the traffic service level of the diversion and reconstruction section. For the delivery scheme lower than the secondary service level, the feasible optimization measures are provided with an optimization of the scheme to improve its service level and capacity.

(2) Interchange reconstruction and expansion

As the key control node project of the highway reconstruction and expansion project, the quality of traffic organization design of interchange reconstruction and expansion directly affects the capacity and efficiency of the whole line. It must attaches great importance to the matching of traffic organization simulation and actual construction in the project of interchange reconstruction and expansion, which give full play to its guiding role in the implementation of traffic reform. At the same time, measures must be taken to survey the traffic flow by unmanned aerial vehicle (UAV) and the data of security operation center to further optimize the simulation, which provide reliable basis for perfecting the traffic scheme.

(3) Diversion vehicles and speed limit demonstration

Under normal circumstances, the design service level of expressway is grade II, but in the implementation of reconstruction and expansion, the service level of the open road section can be reduced by one grade. By employing BIM simulation technology, the necessity of shunting extra large vehicles and limiting speed by 80 km/h can be demonstrated from the aspects of traffic safety and efficiency.
Table 1 Simulation Results

| Traffic flow change | Service level | Confluence speed km/h | Traffic conflict | Emergency queuing |
|---------------------|---------------|------------------------|-----------------|------------------|
| Diversion(before)   | Below level 4 | 48.6                   | high            | Undissipatable   |
| Diversion(After)    | Above level 3 | 53.1                   | low             | Dissipatable     |

The simulation results show that the service level of the highway main line will rise from level 4 to level 3 or above; Traffic conflicts are obviously reduced in the confluence area; And large-scale traffic congestion can be avoided in case of construction or sudden accidents. Simulation analysis proves that the reasonable scheme of diversion and speed limit will ensure the safety and efficiency of the main line traffic operation during the reconstruction and expansion period.

This work assisted the formulation of the overall construction traffic organization scheme, and finally make a determination to carry out traffic protection in five stages. In the third and fourth stages, the speed was limited at 80km/h and vehicles with five axles and above were restricted.

5. Conclusion

This paper mainly introduces the technical breakthrough in the process of traffic organization simulation, studies its technical status and main applications, and shows the advantages of interconnection between traffic organization simulation software and the traffic analysis data of Vissim. The traffic organization simulation highly restores the real traffic conditions under the implementation of the traffic organization scheme from the perspective of 3-D technology, which is conducive to evaluate and analyze the traffic capacity of the diversion section.

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