# Practice of Integrated Management and Platform Construction for Group-level Engineering Project Based on GIS+BIM Technology

Xuejian WANG[1,2,a], Jiayuan WANG[1,2,b], Yuyu ZHANG[3,c], Li-Jie ZHANG[4,d] and Xiaolin ZHOU[4,e]

wustwxj@163.com[a], wangjy@szu.edu.cn[b], tsjzyy@126.com[c], zlj@thsware.com[d], 51048952@qq.com[e]

[1]College of Civil and Transportation Engineering, Shenzhen University, Shenzhen, 518060, China
[2] Sino-Australia Joint Research Center in BIM and Smart Construction, Shenzhen, 518060, China
[3]China Railway Southern Investment Group Co., Ltd., Shenzhen, 518054, China
[4]Shenzhen Thsware Hi-tech Co., Ltd., Shenzhen, 518057, China

**Abstract:** Subway engineering construction is characterized by large scale, cross-temporal and cross-region, etc. In view of the problems of many data sources, poor business collaboration, poor visualization and uneven information management in current projects. From the perspective of integrated management of group-level engineering projects, multi-level project organization and business process management of all-factor data integration, visual management of BIM+GIS data integration have been studied, integrated platform architecture design and development of key technologies have been analyzed based on BIM+GIS technology. An integrated platform independently developed for group-level engineering projects, has realized its engineering application in Shenzhen Metro Line 14. Through implementation of project, the platform meets demand of the group's decision-making level for digitalization, visualization and information management of metro project construction. The economic benefits of the enterprise are improved, and the overall effect is remarkable.

**Keywords:** subway engineering; building information modelling (BIM); geographic information system (GIS); integrated management; platform construction

## 1 INTRODUCTION

Subway engineering projects are characterized by long lines, tight schedule, many participants, complex topographic and geological conditions, etc. The construction management process of metro projects faces problems such as numerous data sources, low integration of project management data, uneven degree of information management, and low degree of business collaboration. Due to the lack of integrated project management tools, it is hard to keep an eye on the real-time status of the project, which leads to inefficient management and control of construction cost, quality, safety and schedule. As the important part of modern city, refinement, refinement, intelligence and standardization are the core requirements of subway construction management today, and there is an increasing demand for using digitalization and information technology to improve the quality and efficiency of subway construction [4].

EMIS 2023, February 24-26, Chengdu, People's Republic of China

DOI 10.4108/eai.24-2-2023.2330659

From the application status, through the integrated application of the Internet of Things, BIM, GIS and other technologies in the construction process, the information system as the carrier to vigorously promote the construction enterprise management concept and management technology innovation, to provide a new idea for the digital management of subway construction. For example, the informatization solution was proposed to help construction enterprises improve efficiency its operation, decision-making and project delivery by optimizing business processes [3]. The combination of building information model (BIM) and geographic information system (GIS) for a webgis-based bridge management system through the format conversion of BIM/GIS integration [5]. The proposed intelligent building based on Internet of Things (IoT) technology was used for providing decision support for building operation and maintenance management through data summary and analysis [2].

With the above background, according to the demand of engineering construction and enterprise-level project integration management, combined with the Internet of Things and other technologies, on the basis of the integration of BIM and GIS [1], the data of various stages of the project can be opened up, the integration management of interconnected digital business and spatial visualization are constructed, and the BIM+GIS group-level engineering integration platform suitable for subway engineering was developed to improve the quality and efficiency of subway engineering management.

# 2 INTEGRATED MANAGEMENT MODE

## 2.1 Business management with total factor data integration

### 2.1.1 Total factor data collection

The construction stage is the key stage of the whole urban rail transit project implementation. The work behaviors that must be completed in order to complete the deliverables of urban rail transit project include construction activities and management activities. Based on the Internet of Things technology, according to the construction units and working procedures of subway projects, real-time monitoring and tracking of personnel, large mechanical equipment, materials, environment and other resource elements involved in construction activities, and the status, location and other (spatiotemporal) acquisition indicators are specified.

### 2.1.2 Project hierarchy classification

In view of the characteristics of subway construction, the integration of group-level engineering projects is based on unified management system and project life cycle, and the different management levels from the site, the area, to the group is established, including regional management at group level, work area management at command department, site management at project department, the main management content is shown in Figure 1.

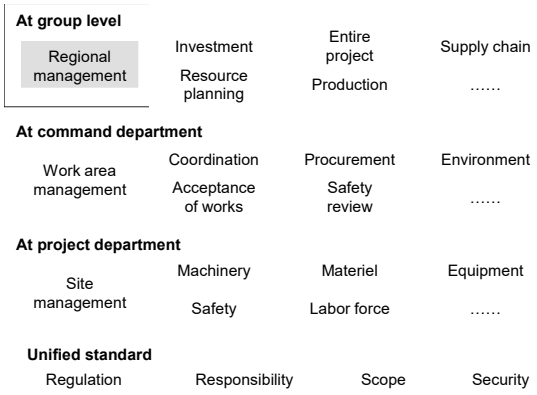


**Figure 1:** Multi-level project management system.

### 2.1.3 Unified organizational structure

For different management levels, different projects and participating units, the organizational structure determines the implementation of work content within the organization. Based on the unified management system, the management organization structure of the group, headquarters, work area and work site is established, the command relationship between different levels and the organizational division between different departments are determined by data flow, information flow and command flow, including the division of work tasks and management functions. The management mode of unified command, coordination and deployment of multi-level organizations is shown in Figure 2.

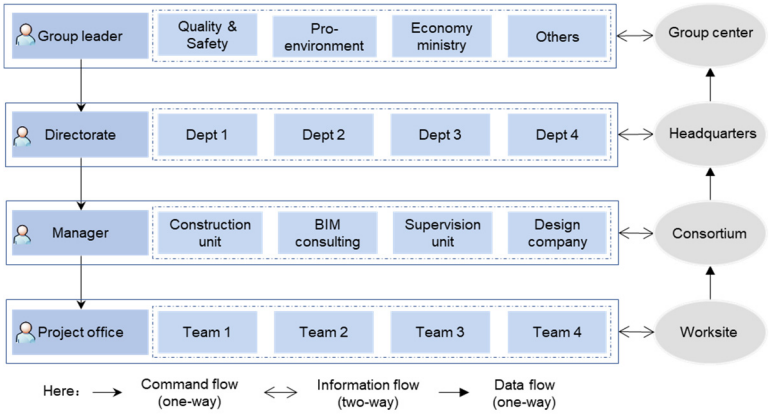


**Figure 2:** Unified organization structure.

### 2.1.4 Business interconnection

In order to open up vertical and horizontal business management processes, various management activity processes are customized according to the actual requirements of management, guided by knowledge and rules (such as PMBOK and WBS standards), and a unified management process system is formed, as shown in Figure 3. Based on the obtained

data of resource elements, process association and combination are performed according to the business division and data flow relationship between different departments including data sharing and data provision to facilitate the business execution of each department.

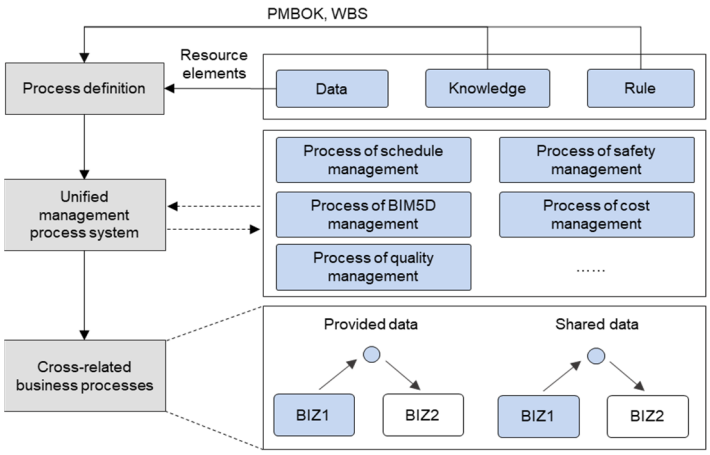


**Figure 3:** Business connectivity framework.

## 2.2 Visual management with GIS+BIM data integration

### 2.2.1 BIM+nD management

Due to the characteristics of large-scale, multi-temporal and trans-regional subway construction, the obtained data are multi-source heterogeneous. the adoption of GIS+BIM can maximally integrate the geospatial data and construction process management data of each work area and site, as shown in Figure 4.

For business management data, based on the WBS unique coding system, BIM models of subway engineering, including stations and tunnels, are connected with the corresponding bill of quantities, construction schedule, resource consumption plan, cost plan and other documents to form an integrated model with multi-dimensional information and visualize the construction progress tracking, cost dynamic control, quality, safety and contract management with BIM+nD.

### 2.2.2 Spatial model integration

In face of multi-source heterogeneous engineering models and geospatial models, based on GIS platform and data integration technology, the simplification, format conversion and coordinate registration of BIM model and geology, oblique photography, topographic image elevation and other models, are carried out. According to WBS component coding and hierarchical organization of models, a complete three-dimensional space environment of above-ground, underground, indoor and outdoor is formed to serve visual construction.

The integration of BIM and GIS data can improve information integrity of the model, and promote macro space management and fine business management of the project.

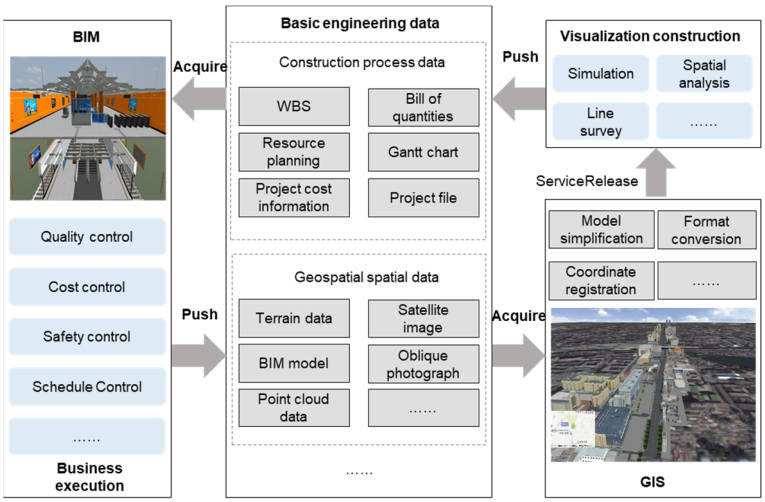


**Figure 4:** Visual management framework of BIM+GIS data integration.

# 3 INTEGRATED PLATFORM CONSTRUCTION

## 3.1 Platform architecture and function

### 3.1.1 Platform architecture design

The core idea of the integrated platform is to combine BIM technology and browser to build 3D spatial scenes and develop diverse functional modules. According to the requirements of business interconnection, the platform integrates a variety of data sources, performs unified computing, scheduling and management. and enables efficient data flow within the platform, timely and accurate delivery to each subsystem or functional module to realize digital and informative management.

In order to realize the combination of technology integration, data integration, management and application integration, and to expand, add or subtract business contents and develop suitable management processes in response to the change in engineering requirements, the integration platform architecture includes infrastructure layer, data layer, application support layer, decision application layer and user layer by level, as shown in Figure 5.

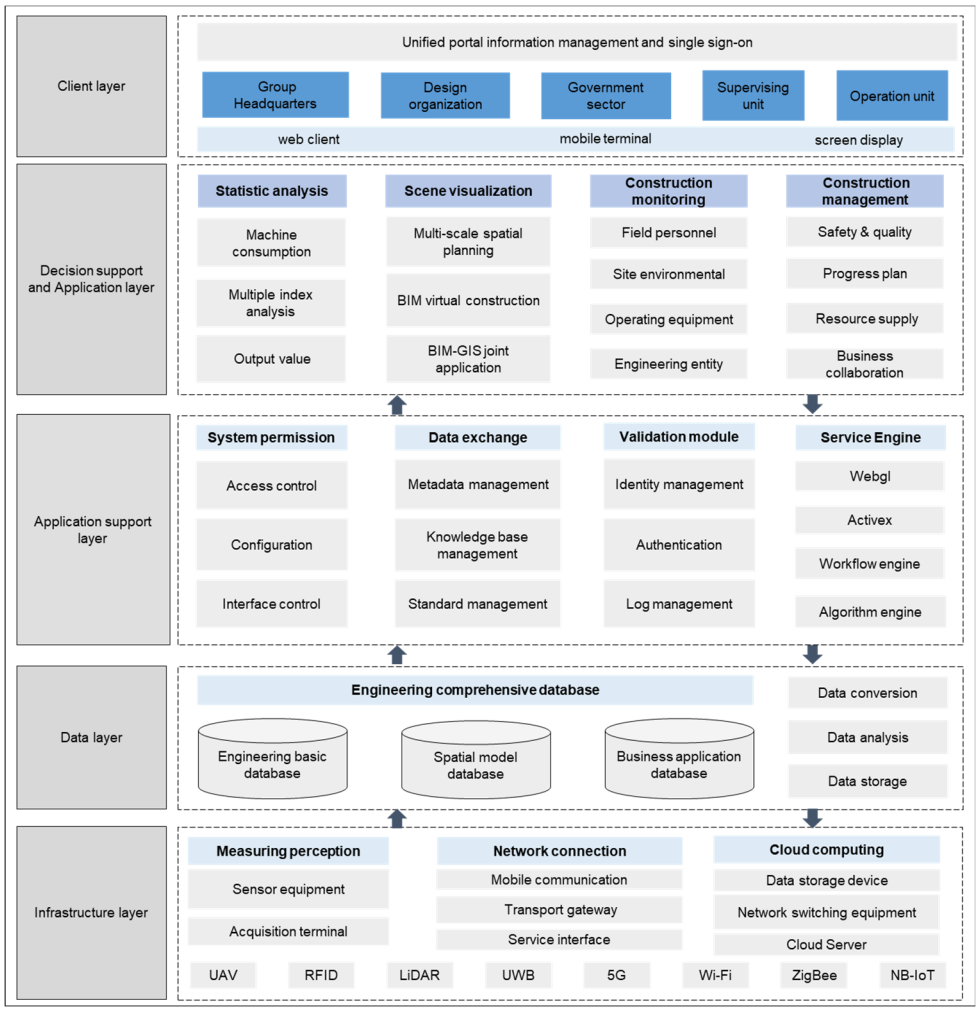


**Figure 5:** Architecture of integration platform.

### 3.1.2 Main function of platform

According to the system construction objectives and demand analysis, the main functional objectives of the platform are to integrate and manage large-scale and massive data, seamlessly connect internal and external systems, three-dimensional real-time roaming, space query and conventional application program expansion, etc., and connect these digital functions based on the platform data.

In order to meet the requirements of multi-level business management, including group-level decision and deployment, work area management of headquarters and site management of project department, the platform takes business management in construction as its centre, and from the perspective of visual construction management application, major functional modules are planned and combined, as shown in Figure 6.

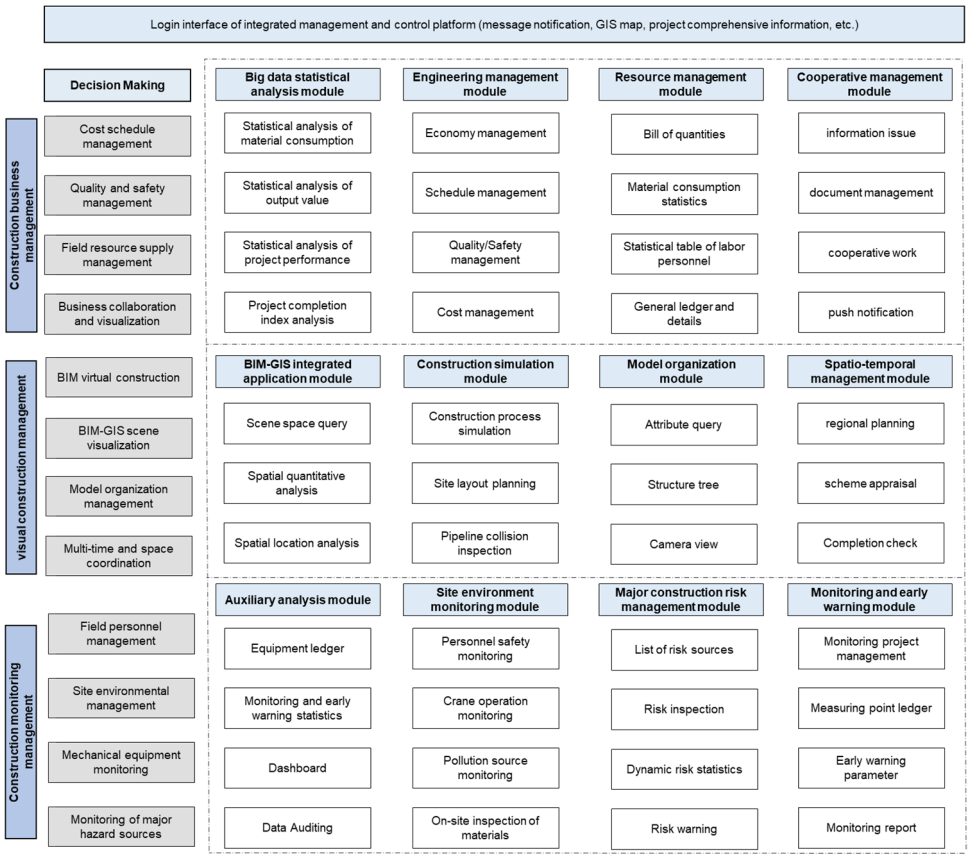


**Figure 6:** Main function of integration platform.

In particular, the construction monitoring and measurement management, as the expanded application part, mainly focusing on personnel, vehicles, large machinery and equipment, hazard sources, hydropower monitoring, environmental protection, safety risk detection, labour supervision, video monitoring and other applications.

In addition to logging in on the Web side, users can also use the command center screen and mobile terminals to operate system functions, carry out project management application anytime and anywhere based on the mobile APP, handle the relevant process online in real time, master the site construction progress, production safety, etc., making project management more convenient and intelligent.

## 3.2 Platform development key technologies

### 3.2.1 Platform architecture technology

The overall architecture of platform follows the SOA service system and is based on the lightweight framework integrated with Spring Boot and Spring Cloud to realize the layered development of platform. The technology system uses B/S structure to layout the server and

browser. The server side uses JAVA language to complete the function of response to request and database operation in the background, the front-end uses WebStorm technology to support JavaScript language and configure HTML pages in the browser.

#### 3.2.2 Service deployment and data collaboration

In terms of Service deployment and data collaboration, REST and Web Service are used to realize information exchange through Http protocol. Through the analysis and extraction of the overall business, the platform business deployment adopts the strategy of front and back-end separation. Based on Spring Boot application framework, each functional module is microserviced to build a microservice system, such as collaboration management, data management, intelligent site and other modules. Each service is deployed independently and encapsulated as business logic, and the Restful API is used to establish lightweight communication mechanisms between services to make calls, collaborate with each other to provide external services, and implement full business applications.

#### 3.2.3 Web side 3D visualization technology

Considering application development environments and system deployment services, SuperMap adopts an open service architecture and loosely coupled services to allow integration with other standard business systems.

Data integration of BIM and GIS realizes high performance visualization display on Web side. Geometric object filtering, triangulation simplification, shell extraction and model merging for BIM models to realize model lightweight. Through hierarchical organization of model LODs and division of octree, a local 3D slice cache file (S3M) is formed, and WebGIS development technology and open-source MySQL database are used to publish 2D and 3D map services with the help of SuperMap iServer to realize efficient dynamic loading of large capacity BIM data in GIS.

## 4 ENGINEERING APPLICATION AND BENEFIT ANALYSIS

This study takes the Shenzhen Metro Line No.14 project as a case study, the integrated management and control platform of GIS+BIM technology application engineering project is built to realize the digital and visual construction management of all ongoing projects owned by China Railway Southern Investment Group (CRSIG).

### 4.1 Engineering application result

#### 4.1.1 Business integrated management

The project starts from the refined management of the work site unit. Based on the data integration of resource elements, the integrated management and control platform provides data interconnection between various departments, including the work area and site engineers, project managers, leaders of the headquarters, and leaders of group departments, and integrates business management modules at all levels. It covers cost management, schedule management, quality management, safety management, collaborative management, system management, etc., to realize the digitization of business management process, as well as the

group's overall control, unified command, decision and deployment of project progress, quality, investment and other objectives, as shown in Figure 7.

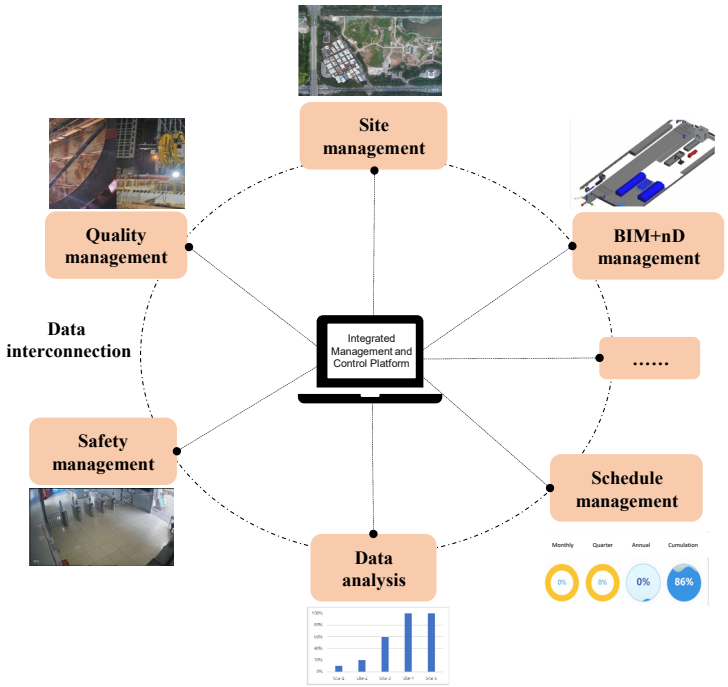


**Figure 7:** Multi-level integrated management and decision making.

### 4.1.2 Space management and visualization construction

In GIS scenario, the lightweight BIM+GIS model is used as the carrier for space management, including model browsing and roaming the model of the entire subway line, including stations, tunnels and surrounding environment of the project, as well as spatial location analysis of the model, so as to form macro-control of the subway line planning, overall construction prospect and project management indicators, as shown in Figure 8.

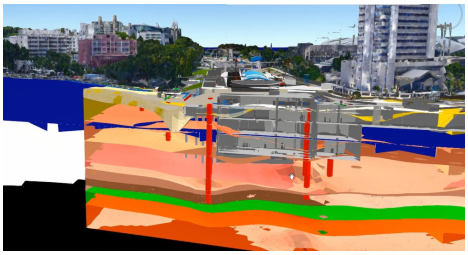

**Figure 8:** Space analysis and management.

In construction phase, the coordination between site layout and surrounding buildings, ground roads and underground environment should be considered comprehensively. The BIM3D

model of project structure itself and the construction site is adopted for site planning, simulation of construction process, collision and comprehensive inspection of pipeline. Therefore, the feasibility of construction scheme is reviewed in advance to ensure construction safety and quality, as shown in Figure 9.

**Figure 9:** Visualization construction.

### 4.2 Benefit analysis

Since the launch of integrated management and control platform and mobile APP for Shenzhen Metro Line No.14 project, and have been put into trial operation on September, 2018. At present, the system technology structure is reasonable, and the running condition is good, which greatly improves the quality of work and efficiency of information processing, reduces the labor intensity of personnel.

The platform can effectively manage the site schedule, safety, quality, engineering economy and technical data, solve the problems such as inefficient collaboration and trouble in data transmission in the process of project management, and realize the digitalization and visualization of total factor management of project, and greatly improve the efficiency of construction business management.

The platform can unify the project management in construction from the group headquarters, project units and participating units, promote multi-party cooperation, improve the effectiveness of project management and communication efficiency among participants, and realize information sharing at all levels of business authorities to break the “resource island” and “application island”.

## 5 CONCLUSIONS

From the perspective of multi-level management of engineering project, GIS+BIM data integration and business integrated management, this study proposes the integrated management mode for group-level project, designs the architecture and main functions of integrated platform, analyses the key technologies for platform construction and development. In engineering practice, through the application of integrated management platform in the whole construction process of Shenzhen Metro Line 14, it can meet demands of the group’s decision-making level for the multi-layer, all-factor, whole-process management in digitization, visualization and informatization of the project, which improves the economic benefits of the enterprise and achieves the significant effect in overall.

## REFERENCES

[1] Bansal, V. K. (2021). Integrated Framework of BIM and GIS Applications to Support Building Lifecycle: A Move toward nD Modeling. J. Journal of Archi Eng. (4) 27.
[2] Lei. Y., B. N., Y. W. (2020). Intelligent power monitoring of building equipment based on Internet of Things technology, Comput Commun. 157, 76-84.
[3] You, Z. & Wu. C. (2019). A framework for data-driven informatization of the construction company. J. Adv Eng Inform. 39, 269-277.
[4] Yu, Z., Peng. H., Zeng. X., Sofi. M., Xing. H. & Z. Z. (2018). Smarter construction site management using the latest information technology. Proceedings of the Institution of Civil Engineers. 172(2), 89-95.
[5] Zhu, J., Yi. T., X. W. & Peng. W. (2020). BIM/GIS integration for web GIS-based bridge management, Annals of GIS. 27 (1), 1-11.