Research and Application of Digitalization in the Whole Life Cycle of Road Maintenance Management

Shan Hu[1, a], Baimin Zhu[2, b], Zhuo Chen[1, c], Bowen Gao[1, d], Xiaodong Liu[1, e]

[1] China Merchants Chongqing Highway Engineering Testing Center Co., Ltd., Chongqing 400067, China

[2] China Merchants Highway Network Technology Holding Co., Ltd., Beijing 100022, China

[a]hushan1@cmhk.com, [b]zhubaimin@cmhk.com, [c]chenzhuo@cmhk.com, [d]gxkfgjb@163.com, [e]lxd@cmhk.com

Abstract

At present, the scale of road maintenance is growing exponentially, and the volume of road maintenance management is increasing.The traditional maintenance project management mode has low management efficiency, poor coordination, and weak awareness of life cycle management. It is urgent to use digital technology to clarify work tasks and projects objectives, standardize the project management process. This paper constructs a three-level project management model and a full life cycle management system model, and builds a project management platform based on the digital technology of multi-level views, so as to realize the normalization, standardization and digitalization of project management in the whole life cycle of highway maintenance engineering. The project management platform has been deployed and applied in Chongqing, Fujian, Zhejiang, Hubei, Guangxi, Yunnan, Anhui and other provinces and cities. It can adapt to different regions, different companies, and different levels of maintenance management models, assisting maintenance managers to improve maintenance management efficiency.

Keywords

Maintenance Management; Whole Life Cycle; Digitalization; Three-level Management; Multi-level View.

1. Introduction

The connotation of construction project management involves the management of the whole process of the project (the whole life cycle of the project), including the decision-making stage, the implementation stage, the use stage; The work of engineering project management is limited to the work in the project implementation stage, with the goal of cost, schedule and quality control. As highway "the repair time" to "comprehensive maintenance time", There are many highway maintenance projects and gradually heavy maintenance tasks. The connotation and objectives of construction project management cannot be directly applied to maintenance project management, and the management level and professional technical ability of maintenance management personnel are uneven, the maintenance management system is not perfect, and the maintenance management system cannot be implemented. The traditional maintenance project management mode cannot meet the actual business needs and the requirements of "delicacy, standardization and normalization" of superior competent departments. It has problems such as untimely tracking of project control (quality, schedule and cost), non-standard project management (safety, contract and information), difficult

communication and coordination among project parties and low efficiency of data transfer and sharing.

With the deepening of "digital China", digital technology has gradually matured and been applied to promote digital industrialization and industrial digital transformation[1]. Based on the relevant requirements of the "14th Five-Year Plan" of the Ministry of Communications, various regions put forward the highway maintenance development plans with the concepts of "digitization of facilities, specialization of maintenance, modernization of management, high efficiency of operation and excellent service". How to use digital technology to establish the whole life cycle maintenance management system and innovative maintenance management mode, improve overall planning, supervision and management of highway maintenance management work such as ability, realize the digital transformation and upgrading of highway maintenance and maintenance engineering project management digitalization upgrade, become a "difference" the key research topic of highway operating units.

In order to solve the problems of information chimneys and management inefficiency in engineering project management, many researchers have conducted relevant studies. Some researchers propose solutions based on the current situation and problem analysis of information technology in engineering project management[2]-[4]. Some researchers have studied the standardization of engineering project management [5]. Some researchers are committed to improving construction efficiency and project management level through information technology such as BIM and GIS[6]-[9]. The above lacks thinking about the whole life cycle management of projects, especially maintenancen projects, in the context of big data.Therefore,this article constructs a three-level project management model at the decision-making level, management level, and execution level, and a full-life cycle management system model of four stages (decision-making-preparation-implementation-completion) of nine links (project research-feasibility study-feasibility analysis-bidding-contract signing-project start-site preparation-process control-delivery-completion), and builds a highway maintenance project management project management platform based on the digital technology integrated with multi-level view (first-level list view, second-level data view, and third-level process view). Realize the standardization,systematic and digitization of the whole life cycle project management of highway maintenance.

2. Business Process of Road Maintenance Project Management
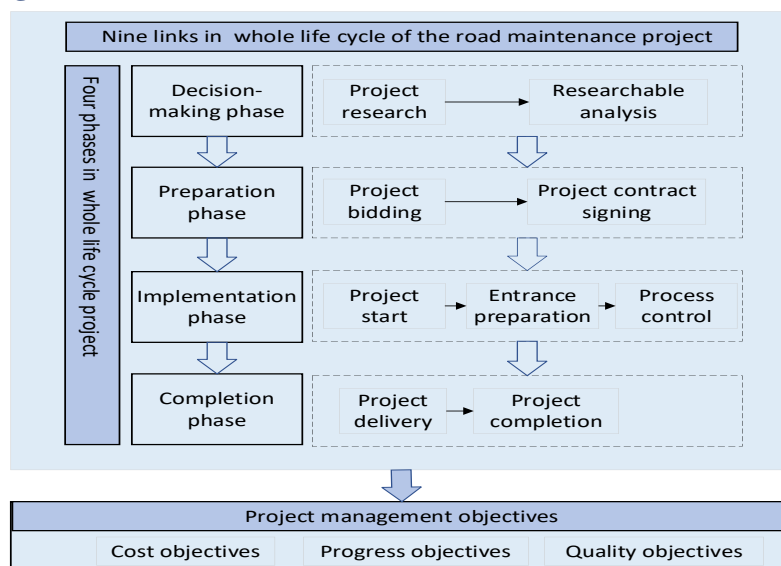
2.1 Section Headings

Fig.1 The whole life cycle of maintenance project management

Referring to the project management process of construction projects, combined with the procedural steps of maintenance projects in the "Highway Maintenance Project Management Measures", the whole life cycle management system model based on the four stages (decision-making - preparation - implementation - completion) and nine links (project research - feasibility study analysis - bidding - contract signing - project start - entry preparation - process control - delivery - completion) is proposed, so as to realize the management coordination of the decision-making level, management and execution level of the project, and achieve the three major goals of schedule, cost and quality. The conservation project management business process is shown in Fig.1.

3. Construction Scheme of Road Maintenance Project Management Platform

3.1 Technology Architecture of Platform

The maintenance project management platform adopts centralized deployment and distributed application to realize the unified management, unified allocation and on-demand invocation of resources. System application services are deployed in multi-instance mode to achieve high availability of the system. The technical architecture system is divided into five layers: environment layer, resource layer, support layer, business layer and user layer. Users include three layers: decision layer, management layer and executive layer. See Fig 2 for the technical architecture system of the platform.
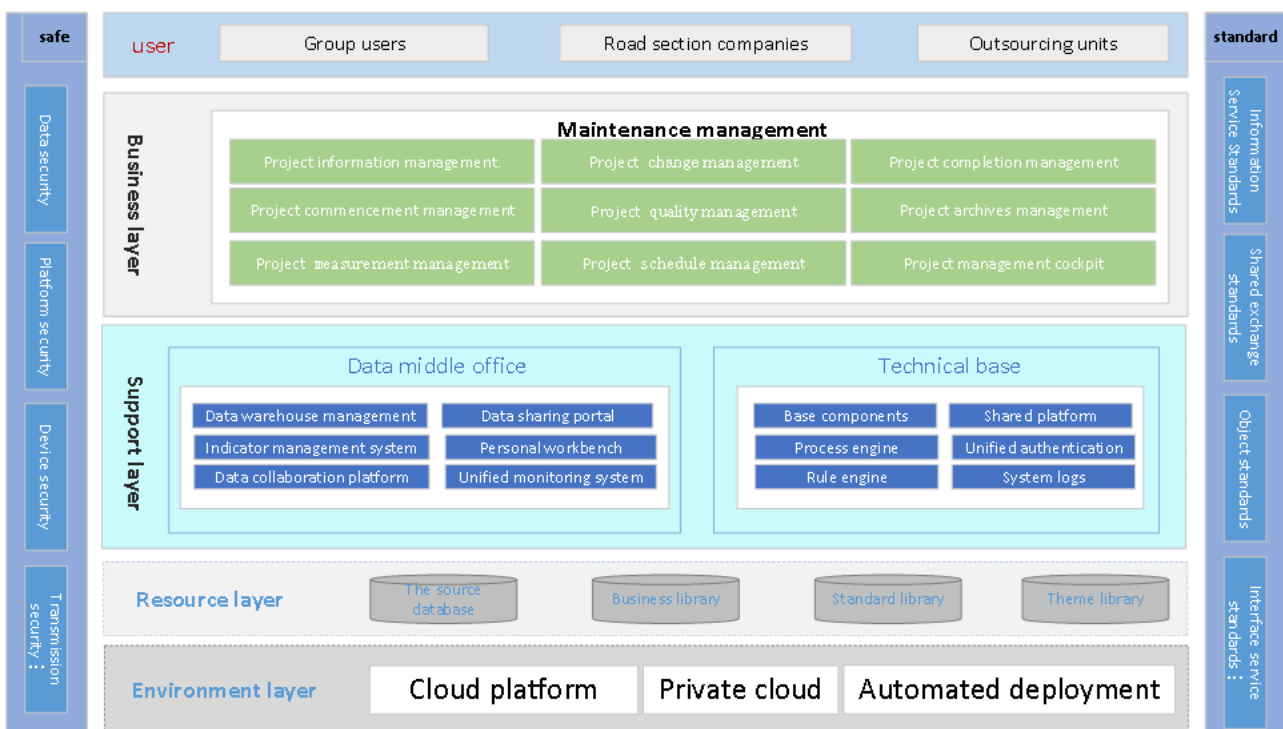

Fig.2 Technical architecture system of Platform

(1) The environment layer is deployed on the cloud environment to ensure the safe, reliable and stable operation of information systems.

(2) The resource layer realizes centralized management, exchange and sharing of resources by establishing a unified highway database.

(3) The support layer is the data middle platform, which breaks through the data barriers in the industry , activates the value of data, realizes the assetization of big data, provides standard unified, fast and efficient data application services for various business scenarios, and provides basic

capabilities such as video output capabilities, Internet of Things control capabilities, business process management, and unified authentication and authentication.

(4) The business layer, with data as the "engine", drives business innovation and application, and promotes the digital construction of project management from the "four stages and nine links" of conservation project management to achieve full coverage of the project management process.

(5) The user layer, user terminal support PC, mobile terminal, data center large screen, etc.

3.2 Functional Design of Platform

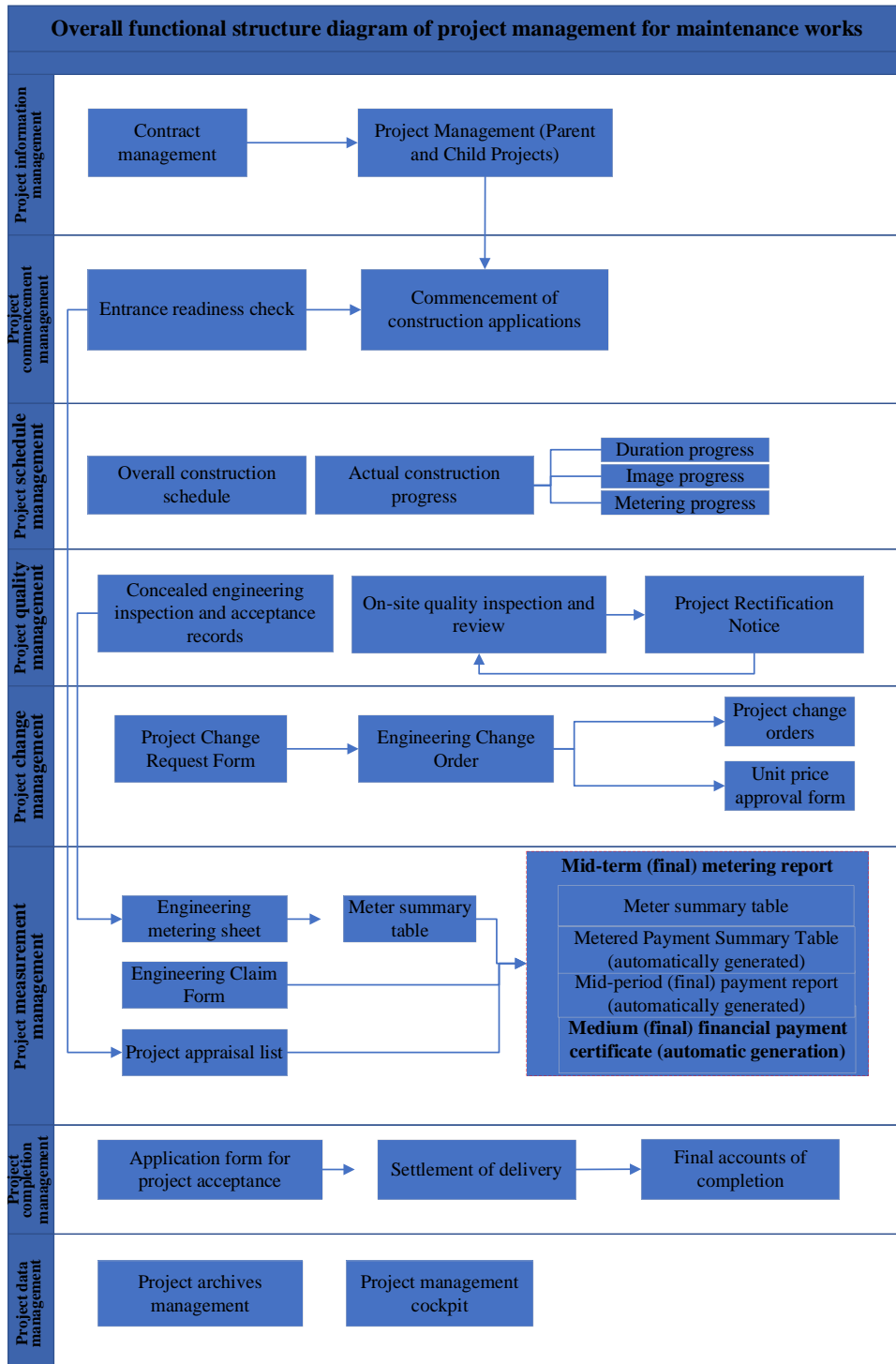### 3.2.1 Features Overview of Platform

Fig.3 Overall functional structure of maintenance project management

Based on the road maintenance project management business process mentioned above, a maintenance project management platform based on the full life cycle should be built. With the help of the information platform, multi-system and multi-functional data resources should be integrated to eliminate barriers between business transmission and promote the implementation of project management system and coordinated development of projects. The project management platform is designed based on multi-level view, among which the first-level list view clearly displays the data of each stage and link of the project in the form of a list. Second level data view, one graph multidimensional, multi-angle display of all the company's project data statistics; The three-level process view runs through the whole life cycle of the project in the form of flow chart, visually displaying the project progress and key node data and time in the process. Specific functions include: basic data management, project overview, start management, schedule management, quality management, change management, measurement management, project management cockpit, project files management, etc. The functional structure of the system is shown in Fig. 3.

3.2.2 Function Points of Platform

(1) Project information management. The project information management function adopts the two-level structure mode. The first-level project takes the project as the object and manages the project time, name and other contents. The second-level sub-project takes the contract as the object, and manages the project overview, contract amount, contract list, project category, etc. The multi-level structure mode of project management collects project information, establishes standardized engineering project database, and realizes hierarchical and hierarchical management and control of projects. The project information management page is shown in Fig 4.
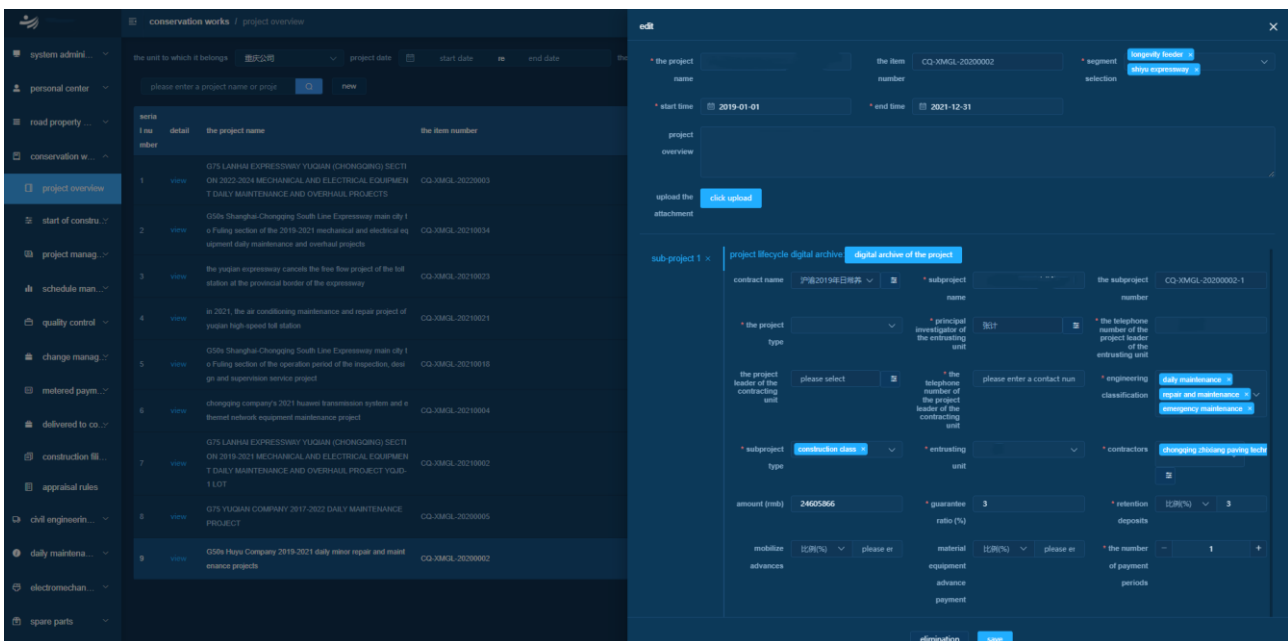

Fig.4 Project information management interface

(2) Project commencement management. Realize the online processing of the whole business of project start, including application for start of construction, inspection and rectification of entry status, and issuance of construction orders.

(3) Project schedule management. Project schedule management includes schedule planning, schedule reporting and schedule automatic statistics. Support the level by level breakdown of the project, the formulation of the schedule plan according to the project stage; Support the use of APP to fill in the update progress in real time. By obtaining the progress reporting data and integrating the

data of other sub-modules, the progress statistics are analyzed from the three aspects of project image progress, measurement progress, and construction period progress.

(4) Project quality management. Quality management includes two categories: concealed project quality inspection, project site quality inspection and rectification. Support mobile APP for quality inspection and rectification acceptance.

(5) Project change management. Change management realizes the online circulation of business processes such as change application, change order issuance, project change order, automatic generation of business documents, online approval of business processes, and synchronously updates the contract list after the change is completed.

(6) Project measurement management.Through the layers of acceptance receipts, intermediate metering sheets, meter summary tables, and financial payment certificates, the measurement and payment report book is automatically generated, including the intermediate metering sheet, the metering summary table, the metering payment summary table, the list payment statement, and the financial payment certificate, which greatly improves the measurement efficiency and accuracy.

(7) Project completion management. It realizes the online circulation of business such as delivery acceptance application, delivery settlement, and completion final account, automatically generates the delivery settlement report and the completion final account report, and can transfer investment projects to solid construction when delivering work.

(8) Project archives management. Create a folder according to the project, automatically gather all the process files and archive them according to the project management process, automatically complete the collection and collation of the delivered data, and solve the problem that paper data is easy to lose, not uniform and not standardized.

(9) Project management cockpit. Through real-time data collection and statistics, multi-level structure mode is adopted for design, it supports "drill-through query"to achieve layer-by-layer refinement and in-depth analysis of indicators. A multi-dimensional and multi-angle display of all the company's project process data statistics (project overview project progress, project costs, project quality inspection, changes, measurements, etc.), effectively help maintenance managers to keep abreast of the overall operation of the project, as shown in Fig.5. Through the dynamic project list, drill into and query the whole life cycle process, key time nodes, key data, and process data analysis statistics of each stage, and can directly link to the submodules of the corresponding stages, as shown in Fig.6.

Fig. 5 Maintenance project management overall data "one picture"

Fig. 6 Design of maintenance project life cycle management

4. Conclusions and Outlook

4.1 Conclusions

This paper studies the three-level management model of the project based on the decision-making level, management level and execution layer, proposes a four-stage nine-link model such as decision-making, preparation, implementation, completion and project research, feasibility study analysis, bidding, contract signing, project start, entry preparation ,process control ,delivery ,completion. It also creates a highway maintenance project management project management platform with a multi-level view such as first-level list view, second-level data view, and three-level process view, which realizes the following values:

The level of standardization of project process control has been improved. Relying on the "four stages and nine links" to build a standardized and standardized project management system, realize the whole life cycle control of the project, effectively monitor the progress, control the cost, transform the result control into process control, and comprehensively improve the management efficiency.

Project synergy efficiency is improved. Traditional project management, because of the greater impact of time and place, the flow of information is slower. The project management platform realizes online project management and approval through PC and mobile terminal. Helps to strengthen cross-departmental communication and collaboration and eliminate information silos within the company.

Project file management is intelligent and standardized. Different from the traditional paper form of project files is not easy to preserve, collection and collation difficulties, but also different from the project electronic file relevance degree is poor, the platform project archives to achieve project process files automatic collection classification, layer by layer association, query efficiency, in the

use rate to improve, for the maintenance managers to carry out maintenance decisions to provide an effective basis.

The statistical analysis of project data is efficient and accurate. Different from the traditional project management data collection, collation, statistics, information synthesis and analysis process is complicated, low accuracy, poor timeliness, maintenance managers can not grasp the project situation in time, resulting in extensive management. The multi-dimensional, multi-angle, multi-level real-time display of process management data and analysis results of the cockpit of the platform project, the statistical analysis of the data is efficient and accurate, and the decision-making of the maintenance manager can be based on evidence, so as to realize the refined management of the project.

4.2 Outlook

The project management platform based on the research on the whole life cycle management of the project has basically realized the standardization and refined management of the project. The next step will be to access smart devices to provide maintenance managers with richer business data, starting from project cost progress monitoring, project data analysis and mining, to achieve the concept of "managing" project data to "using well" data, and further improving the digital level of maintenance management.

Acknowledgments

References

[1] Bing-Ying Xie,Qian Zhang,Jian Fu. Analysis on the Function Construction of Engineering Project Management Informatization in Survey and Design Enterprises[P]. Proceedings of the 3rd Annual 2017 International Conference on Management Science and Engineering (MSE 2017),2017.

[2] Huang Yao,Shi Qian,Zuo Jian,Pena-Mora Feniosky,Chen Jindao,Yi Wen. Research Status and Challenges of Data-Driven Construction Project Management in the Big Data Context[J]. Advances in Civil Engineering, 2021,2021.

[3] Liangliang Yu,Gao Yang,Zhang Yin,Mingli Ding. Application of Computer Application Technology in Engineering Project Management[J]. IOP Conference Series: Materials Science and Engineering, 2019, 688(5).

[4] Xinghua Du,Miaoling Han,Guofeng Zhang,Zhang Yin,Mingli Ding. Construction of Engineering Project Management Informatization[J]. IOP Conference Series: Materials Science and Engineering,2019,688(5).

[5] Longhua Liu,Liu Longhua. Comparative Analysis of the Mechanism of Engineering Project Management Standardization[J]. IOP Conference Series: Earth and Environmental Science,2020,526(1).

[6] Youren Liu,A.T. Zub. Research on the Application of BIM Technology in the Efficiency and Effectiveness of Construction Project Management[J]. Journal of Physics Conference Series,2020,1574(1).

[7] Peter Mesaros,Mesaros Peter,Spisakova Marcela,Mandicak Tomas. Analysing the implementation motivations of BIM Technology in Construction Project Management[J]. IOP Conference Series: Materials Science and Engineering,2020,960(4).

[8] Chunyan Peng,Sai Liu,Hongwei Yi. Research on the Influence of BIM Technology on Engineering Project Management and Its Development Countermeasures in the New Period[C]//.Proceedings of 2019 International Conference on Education,Management,Social Science and Humanities Research(EMSSHR 2019).Clausius Scientific Press,2019:898-902.

[9] Xiaoyu Yang. Research on Building Information Model and Construction Project Management based on GIS Spatial Analysis[C]//.Proceedings of 2nd International Conference on Business, Economics, 2020: 270-274.DOI:10.26914/c.cnkihy.2020.001405.