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Original Research Article

Research on Intelligent engineering management mode from the perspective of project lifecycle

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Abstract: Against the backdrop of global economic integration and rapid technological development, engineering projects are facing increasingly complex demands and challenges. This article explores the application and optimization strategies of intelligent engineering management mode from the perspective of the entire project lifecycle. By analyzing the characteristics and challenges of each stage of project planning, design, construction, and operation, a solution based on intelligent technology is proposed, and its impact on improving project management level is discussed, aiming to provide scientific and reasonable guidance for enterprises.

Keywords: Project lifecycle; Intelligent engineering; Management model

1. Introduction

The traditional engineering management model seems inadequate in dealing with these changes, especially with the continuous expansion of project scale and increasingly frequent cross regional cooperation. Intelligent engineering management, as an emerging management concept and technological means, provides new ideas for solving these problems. By integrating advanced technologies such as big data, the Internet of Things, and artificial intelligence, the intelligent engineering management model can achieve comprehensive monitoring and optimization of the entire project lifecycle, thereby improving the overall efficiency of the project.

2. Application of intelligent engineering management mode

2.1. Intelligent application in the planning phase

Geospatial analysis system integrates multi-source data to provide scientific basis for project site selection. Machine learning algorithms process massive historical project data, identify potential risk factors, and optimize resource allocation plans. Digital twin technology builds virtual models in the early stages of planning to simulate the implementation effects of different solutions and assist decision-makers in selecting the optimal solution. Intelligent requirement analysis tools use natural language processing technology to extract key information from a large number of documents and build a structured requirement database. A market analysis platform based on big data, combined with regional economic development trends and population mobility characteristics, provides data support for project positioning and functional planning. The deep application of visualization technology makes planning schemes more intuitive, enhances the scientificity and operability of decision-making. The introduction of smart contracts has improved the efficiency and transparency of collaboration among all parties in the planning phase, while blockchain technology ensures the authenticity and traceability of planning data, reducing the risks caused by information asymmetry. The environmental assessment system integrates multidimensional data such as meteorology and geology to predict the impact of projects on the environment. The investment estimation model combines market dynamic data to provide more accurate cost forecasts.

2.2. Intelligent application in the design phase

The intelligent transformation in the design phase is reflected in the digitization and automation of the entire process. The parametric design platform allows designers to quickly generate multiple feasible solutions by adjusting parameters. The structural optimization system uses finite element analysis and genetic algorithm to find the optimal design solution while meeting the requirements of the specifications. The energy consumption simulation software seamlessly integrates with the design platform to achieve intelligent design of green buildings. The collaborative design platform integrates data from multiple disciplines such as architecture, structure, and mechanical and electrical engineering to detect design conflicts in real-time. The intelligent drawing review system is based on deep learning algorithms to automatically identify design specification compliance and improve review efficiency. The material selection database combines project characteristics and performance requirements to recommend the optimal material combination scheme. The deep application of virtual reality technology makes the display of design results more intuitive and immersive. The performance simulation system predicts building lighting, ventilation, energy consumption and other indicators to optimize design schemes. Intelligent drawing tools automatically generate construction drawings that meet standards, reducing manual errors. The design change management system tracks the impact of each change to ensure design consistency. Accumulate design experience in the knowledge base system to provide reference for new projects.

2.3. Intelligent application during the construction phase

The intelligent management of the construction site depends on the deep integration of the Internet of Things and mobile Internet technology. The intelligent helmet integrates multiple sensors to monitor the position and physiological status of personnel in real time. The application of automated construction equipment such as intelligent wall building robots and concrete 3D printers has improved construction efficiency and quality. The unmanned aerial vehicle inspection system regularly collects construction site data and constructs a three-dimensional real-life model. The progress management system integrates multiple data sources, dynamically adjusts construction plans, and predicts completion times. Quality inspection equipment enables automatic data collection and analysis, improving inspection efficiency and accuracy. Intelligent warehousing system optimizes material management, achieving precise delivery and inventory control. The environmental monitoring system collects real-time construction environment data to ensure the implementation of green construction requirements. The personnel management system achieves precise attendance and permission management through biometric technology, and the intelligent security warning system analyzes construction site data to promptly detect safety hazards. The equipment management system tracks the usage status of mechanical equipment and optimizes equipment scheduling. The mobile application platform enables rapid reporting and handling of on-site issues.

2.4. Intelligent application during the operation and maintenance phase

The intelligent application in the operation and maintenance stage focuses on predictive maintenance and energy efficiency management. The equipment health monitoring system collects real-time equipment operation data through sensor networks and constructs equipment health records. The fault prediction model analyzes historical data, provides early warning of potential faults, and develops preventive maintenance plans. Optimizing equipment operation strategies for energy management systems to reduce energy consumption costs. Intelligent inspection robots replace manual labor to complete routine inspection tasks, improving inspection efficiency and safety. Digital twin technology builds a virtual operation and maintenance model that supports remote diagnosis and decision-making. The user behavior analysis system optimizes space utilization efficien-

cy and enhances user experience. Blockchain based operation and maintenance data management ensures data authenticity and traceability. Energy efficiency optimization system analyzes building energy consumption data and identifies energy-saving potential. The intelligent lighting system automatically adjusts based on ambient lighting and personnel activities. The security monitoring system integrates facial recognition technology to improve the level of security management. Accumulate fault handling experience in the operation and maintenance knowledge base to improve operation and maintenance efficiency.

3. Optimization strategy for intelligent engineering management mode

3.1. Data driven decision support

The construction of a data-driven decision support system is the core of optimizing intelligent engineering management models. Multi source data collection systems integrate project lifecycle data, including design drawings, construction records, equipment operation logs, etc. Data cleaning and preprocessing techniques ensure data quality and provide a reliable foundation for subsequent analysis. Machine learning algorithms play an important role in engineering management decision-making, with predictive models analyzing historical data to accurately predict project progress and costs. Classification algorithms identify potential risk factors and assist in developing risk response strategies. Cluster analysis reveals hidden patterns in the data, providing a basis for optimizing resource allocation. The application of deep learning technology in the field of image recognition has improved the efficiency and accuracy of construction quality inspection. The application of visualization technology makes complex data easier to understand, interactive dashboards display key indicators in real-time, and support dynamic decision-making. 3D visualization technology presents the overall picture of the project, helping managers grasp the overall situation. Data storytelling technology transforms analysis results into intuitive narratives, improving decision-making and communication efficiency. The establishment of a data governance system ensures data security and compliant use, and a data permission management system controls data access permissions for different roles. The data audit mechanism tracks data usage records to ensure data traceability. The data quality monitoring system continuously evaluates the accuracy of data, promptly identifies and corrects data issues.

3.2. Platform construction for collaborative work

Cloud computing based collaborative platform enables real-time collaboration among multiple parties, breaking geographical limitations. The document management system supports version control and permission management to ensure secure file sharing. The task allocation system intelligently assigns tasks based on members' abilities and workload. Real time communication tools integrate multiple communication methods such as text, voice, and video to improve communication efficiency. The online conference system supports remote collaboration and reduces travel costs. The project management module integrates data such as progress, cost, and quality to provide a comprehensive project view. The knowledge base system accumulates project experience and provides reference for new projects. The mobile application platform supports real-time reporting of problems and progress by on-site personnel, and the workflow engine automates the approval process to improve work efficiency. The intelligent reminder system promptly alerts relevant personnel based on task priority and deadline. The data analysis module provides project performance reports and supports continuous improvement. Platform integration capability is an important consideration in the construction of collaborative work platforms, and open API interfaces enable seamless integration with other systems. Data exchange standards ensure data interoperability between different systems. The single sign on system simplifies the user access process and improves usability.

3.3. Security and risk management

The establishment of a security guarantee system is the foundation of intelligent engineering management, and the identity authentication system adopts multi factor authentication technology to ensure the authenticity of user identity. The access control system is based on role and permission management, limiting the scope of data access. Data encryption technology protects sensitive information and prevents data leakage. The network security protection system monitors network traffic in real-time, identifies and blocks potential attacks. The terminal security management system controls device access to prevent unauthorized devices from accessing the network. The security audit system records all operation logs and supports post event traceability and analysis. The risk identification system continuously monitors the project environment and identifies potential risks. The risk assessment model quantifies the impact and probability of risk occurrence, and supports risk prioritization. The risk response strategy library provides standardized response measures to improve response efficiency. The risk monitoring system tracks the status of identified risks and provides timely warnings of risk changes. The emergency plan management system develops and drills emergency plans to improve emergency response capabilities. The business continuity plan ensures that critical businesses can quickly recover in the event of a disaster. The insurance management system integrates various insurance information and optimizes insurance strategies. The safety training system regularly conducts safety awareness training to improve the safety literacy of all staff.

4. Future development trends and challenges

4.1. Technological innovation and integration

The field of intelligent engineering management is undergoing unprecedented changes, and technological innovation has become the core driving force behind this change. The rapid development of technologies such as big data, artificial intelligence, and the Internet of Things provides accurate data support and decision-making assistance for various stages of the project lifecycle. By integrating these advanced technologies, real-time monitoring and optimization adjustment of projects can be achieved, significantly improving engineering efficiency and quality. During the design phase, utilizing virtual reality technology for simulation can help identify potential issues in advance and develop solutions. During the construction process, the application of intelligent robots and automation equipment not only improves work efficiency, but also reduces the risk of human error. In addition, the use of cloud computing platforms promotes information sharing and collaborative work, making cross regional team collaboration more efficient and convenient.

4.2. Regulatory compliance and ethical challenges

With the widespread application of intelligent technology, relevant regulations and ethical standards are also constantly evolving. Data privacy protection has become one of the focuses of attention, and ensuring compliance with laws and regulations when collecting, storing, and processing large amounts of personal information is a problem that every enterprise must face. In addition, with the deepening of automation, there is an increasing demand for fairness and transparency in algorithms. It is particularly important to establish a strict review mechanism and accountability system in order to safeguard public interests and social stability. At the same time, industry self-discipline should be strengthened, the concept of technology for good should be advocated, and social harmony should be promoted. Addressing these issues requires joint efforts from the government, enterprises, and research institutions to establish a comprehensive legal framework and technical regulatory system.

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5. Conclusion

In summary, the engineering management model based on intelligent technology provides new opportunities and challenges for improving the management level of the entire project lifecycle. By utilizing advanced technologies and methods such as big data, the Internet of Things, and artificial intelligence, comprehensive monitoring and optimization of projects can be achieved, significantly improving project transparency, collaboration, and decision-making efficiency. However, in practical applications, there are still many technical and management challenges to be faced, such as data security, regulatory compliance, etc. In the future, with the continuous innovation and improvement of technology, intelligent engineering management mode will play an important role in more fields and create greater value for enterprises.

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