

The Influence of Engineering Project Management Measures on the Sustainable Development of Construction Industry

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Abstract. Against the backdrop of sustainable development, this paper focuses on the transformation needs of the construction industry. Addressing the deficiencies of current relevant research in terms of environmental dimensions, social perspectives, and digital transformation, it adopts a case study approach. Taking the Project Section A1 of Xiamen Third East Passage as a specific example, the paper conducts an in-depth analysis of the impact of engineering project management measures on the sustainable development of the construction industry from both environmental and economic dimensions, and also carries out a project impact analysis from the social dimension. The study finds that through the implementation of strict environmental protection measures, digital and intelligent management, and other initiatives, this project has achieved remarkable results in reducing environmental impact, improving economic benefits, and enhancing social credibility, thereby providing a practical model for the sustainable development of the construction industry. The purpose of this research is to enrich the theoretical system in the interdisciplinary field of sustainable development and engineering project management in the construction industry, and to provide practical guidance for construction enterprises to integrate the concept of sustainable development into project management.

Keywords: Project Measures, Construction Industry, Sustainable Development.

1. Introduction

As global climate change intensifies, the construction industry, a major energy consumer and carbon emitter is undergoing transformative pressure, with its sustainable development progress becoming a focal point of societal concern [1]. Driven by sustainability principles, the sector must transition from traditional operational models to sustainable development frameworks. Project management, being a critical operational element for every enterprise in this industry, directly determines whether the sector can achieve its sustainable transformation through scientifically sound, rational, and effective measures. Current research exhibits limitations in three key areas: insufficient exploration of environmental dimensions, inadequate attention to social dimensions, and limited studies on digital transformation. These shortcomings significantly impact the industry's capacity to realize sustainable development goals.

This study systematically analyzes current engineering project management practices through case studies, examining environmental and economic dimensions of operational strategies while

evaluating the industry's sustainable development. The research employs case analysis methodology, utilizing the author's internship experience at China Communications Construction First Highway Bureau Group's Xiamen Jin Bridge- Xiamen Third East Channel Project (Contract Section A1) as a concrete example. The investigation integrates firsthand project data and technical documentation to provide comprehensive insights into the initiative's societal impacts.

This study contributes to enriching the theoretical framework at the intersection of sustainable development and engineering project management in the construction industry, providing theoretical support for subsequent research. Practically, it offers reliable guidance for enterprises in the sector to integrate sustainability concepts into project management practices. The research aims to optimize management models, enhance resource and human capital utilization efficiency, and minimize environmental impacts on project operations, corporate management, and the entire industry. It also provides practical recommendations. By analyzing the project's characteristics, this study examines its cross-strait influence in Xiamen, while exploring how emerging technologies like BIM and digital management approaches, including BIM coordination platforms and smart construction, impact project operations and drive sustainable development in the construction industry.

2. Theoretical basis of engineering project management

Taking the sustainable development theoretical system as the core framework, this study combines the triple bottom line theory, ecosystem service theory, BIM theory and digital project management theory and other subdivision theories to form a multi-dimensional theoretical support system. Sustainability is a well-calibrated methodology that assigns equal weight to the economy, society, and environment [2]. As a major contributor to environmental impacts, the construction industry should more actively embody sustainability principles to promote its own sustainable development. The TBL framework (Triple Bottom Line), designed by Elkington in 1996, emphasizes that enterprises must simultaneously meet "environmental, economic, and social bottom lines" representing a concrete extension of sustainable development theory at the project level [3]. The ecosystem services metaphor has given rise to powerful tools and approaches for identification and measurement of a wide range of human benefits arising from the natural world [4]. Its core is natural ecosystem for human beings to provide benefits, in this project the corresponding environmental protection measures adopted reflect that the protection of ecological environment also plays a role in promoting the completion of the project; BIM (building information modeling) is the digital expression of the physical and functional characteristics of architectural projects and can realize the sharing of data and information in the whole lifecycle of architectural engineering and promote the collaborative work of all stakeholders in architectural engineering [5]. At the national level in China, digitization is receiving increasing attention. The development of digitalization will be the future direction of the country for some time [6]. This theory can make up for the shortcomings of sustainable development theory in technical details, while enriching the theoretical system at the intersection of engineering project management and sustainable development, and increasing the depth of research.

3. Case studies

3.1. Project overview

The third east channel of Xiamen begins near Xiangshan Yacht Club in Siming District, Xiamen Island. The main route first extends north along Huandao Road via a tunnel to Guanyin Mountain,

then crosses the eastern waters of the island eastward by bridge, with its endpoint connected to Xiang'an New Airport through an interchange and the concurrent construction of the Xiang'an Branch Line. Section A1 primarily includes Guanyinshan Beach Bridge, non-vessel-operated navigation bridges near the island's coastal zone, non-vessel-operated bridges west of Liwudian's roadway, Liwudian Navigation Bridge, and partial roadbed works. This project embodies the company's new mission in cross-sea bridge construction, leveraging technological innovation and management excellence while utilizing local corporate resources. It aims to secure market opportunities through on-site operations, cultivate management and technical talent, produce significant scientific achievements, and set a benchmark for high-quality project management and sustainable development within the Group.

3.2. Analysis of measures and impact mechanisms adopted by the project

The project has established detailed safeguard measures for water pollution control, land conservation, noise management, and the protection of Chinese mitten turtles and white dolphins. The project team has also set up an environmental protection system, strictly ensuring its stable operation to guarantee smooth implementation of environmental initiatives. Each staff member is assigned clear environmental responsibilities to ensure compliance.

In highway bridge construction, water resource conservation and rational utilization constitute a vital component of green ecological principles [7]. To address water pollution control and land preservation, measures such as steel casing pile drilling with circulating slurry, monitoring anti-pollution curtain effectiveness, and controlling suspended sediment from construction vessels are implemented. Construction vessels are prohibited from discharging wastewater into the sea; collected sewage is processed by certified facilities. Vessel management protocols prevent oil spills. For land protection, temporary land use outside designated red lines utilizes barren wasteland that is restored to its original state post-construction. Temporary sites are minimized and rehabilitated promptly after completion. All main roads in residential areas achieve 100% greening, while exposed soil surfaces are covered to prevent erosion.

During bridge construction, noise and vibration are inevitable, which may affect surrounding residential areas [8]. To mitigate these impacts, first is use low-noise equipment and comply with emission standards. Second is slow down vehicles and prohibit honking near sensitive points during transportation, avoiding construction zones when necessary. And then, monitor underwater noise from offshore pile driving, adjust noise levels, implement protective measures, and schedule high-noise operations to avoid peak white dolphin breeding periods. At last is install temporary sound barriers at sensitive locations, schedule noisy operations during non-residential hours, keep machinery away from residential areas, and notify residents when continuous nighttime work is approved.

Historically, the Chinese mitten crab (*Pinctula sinensis*) was extensively harvested as an economic species in Xiamen waters. The Liwudian area of Xiamen once served as China's largest production zone for this species and remains the only marine area where a sustainable fishery was established [9]. The Chinese white dolphin (*Sousa chinensis*), a nationally protected species under China's first-class priority list, is also classified as "vulnerable" on the IUCN Red List of Threatened Species [10]. To protect these marine creatures, conservation efforts focus on three key measures: enhancing artificial breeding programs and stock enhancement releases, strictly prohibiting habitat destruction and sewage discharge into protected areas, and scheduling low-impact operations during breeding seasons (June-September) in remote coastal zones. For the Chinese white dolphin, authorities have established a dedicated conservation task force with certified observers,

implemented management protocols and emergency response plans, avoided high-impact activities during breeding periods (April-August), and intensified public education initiatives. Specific measures include: designating "slow-speed zones" to restrict vessel speeds, monitoring underwater noise levels, applying acoustic deterrents when necessary, extending observer hours, adjusting navigation routes, installing noise-reducing equipment on vessels, and developing comprehensive monitoring protocols.

During the construction of this project, comprehensive environmental protection measures were established and effectively implemented. Special emphasis was placed on three key areas: water pollution control, noise reduction, and conservation of rare marine resources. Targeted prevention measures were also adopted for other aspects. These coordinated protective measures collectively formed an integrated environmental protection system. Such initiatives not only demonstrated the green philosophy and social responsibility in project development but also laid a solid foundation for successful completion. Furthermore, they provided valuable examples of harmonious coexistence between engineering projects and ecological environments.

3.3. Related operation management measures and economic dimension impact analysis

In recent years, intelligent construction technologies powered by BIM have experienced rapid development, achieving significant progress in the "full lifecycle management" of engineering projects. The emergence of smart construction sites has created new opportunities for bridge engineering management [11]. For this project's digital and intelligent management, BIM technology serves as the core platform. By focusing on key objectives, the construction process is deeply integrated with advanced intelligent technologies. Through information visualization, controllability, and smart solutions, the project ensures comprehensive oversight of on-site operations to achieve high-quality completion. By integrating various information systems and aligning data standards, the project implements digital-driven management across all aspects, enhancing capabilities in data extraction, transmission, and interaction. This ultimately establishes a unified digital platform for construction processes, realizing the overarching goal of the "Digital Intelligence Third East Corridor".

Specifically, the application of BIM collaborative management platform ensures effective data collection and sharing for project operations. Through intelligent multi-source IoT technologies at the front end, information is automatically collected and uploaded to the data center. Integrated with the project management system, this enables visualized and refined management of key elements such as quality control and schedule tracking, providing integrated decision-making support. The BIM system framework facilitates comprehensive oversight across multiple dimensions including personnel, machinery, materials, methodologies, and environmental conditions [12]. Meanwhile, smart construction site management systems are employed to integrate with real-name registration systems for worker management and payroll processing, while utilizing BeiDou navigation technology for personnel positioning and emergency alerts. All relevant data is displayed on an integrated emergency platform, supported by technical solutions featuring real-time visualization and cross-departmental information sharing.

Intelligent construction is primarily supported by BIM and AIoT technology platforms, focusing on intelligent monitoring to achieve "intelligent management". This is mainly reflected in two aspects. One is the steel structure main tower shell and caisson manufacturing are equipped with smart processing equipment in the factory. By integrating BIM technology to optimize the manufacturing process and utilizing welding robots, video installations are installed in key areas and connected to the BIM system. Another is the large-volume concrete intelligent temperature control

platform integrates multiple functions. Combining BIM models with GIS positioning, it constructs concrete models and enables intuitive analysis of temperature parameter changes. Through cross-application of BIM models and GIS platforms, it achieves geographical positioning of models and enhances spatial analysis capabilities, creating a simulated three-dimensional construction site environment. This integration not only improves the accuracy of construction simulations but also significantly enhances the intuitiveness of progress tracking and resource management [13].

BIM technology demonstrates extensive applications across the entire construction process. Key implementations include: Firstly, construction plan simulation and optimization through model-based problem identification to support decision-making. And then, site layout optimization using drone oblique photography with modeling software. Thirdly, intelligent BIM drawing review for collision detection and report generation to optimize construction. Next, 3D visualization progress management that replaces traditional two-dimensional drawings with structural and pipeline layouts, enabling clear design intent communication and achieving "what you see is what you get" results [14]. Finally, BIM+AR technology integrating models with real-world environments, which significantly enhances work efficiency, reduces error rates, and cuts costs throughout the project life cycle [15].

Digital and intelligent management delivers substantial economic benefits. By optimizing material utilization, it prevents quality defects that reduce rework costs while minimizing equipment failures and maintenance expenses. The system enables early detection and resolution of construction issues, enhances labor management efficiency, and achieves efficient equipment scheduling with smart construction control to shorten project timelines. Furthermore, it reduces safety risks, thereby decreasing financial losses from accidents and schedule delays. Through data sharing and informed decision-making, redundant management processes are streamlined, reducing operational costs and improving management accuracy. These insights also serve as valuable references for future projects, ensuring long-term corporate profitability. The practical implementation of digital and intelligent management strategies provides industry benchmarks for highway and bridge engineering projects, helping prevent cost overruns caused by similar mistakes in other initiatives.

3.4. Comprehensive social impact of the project

At the public level, the project's stringent environmental management measures carry profound significance. The precise control of water pollution and effective noise reduction during construction not only prevented environmental damage to surrounding communities, allowing residents to maintain their daily routines throughout the project period, but also demonstrated the nation's commitment to prioritizing people's livelihoods and ecological conservation in advancing peaceful cross-strait relations.

At the industry level, the innovative application of digital and intelligent management of projects, such as BIM collaborative management platform, smart construction site system, etc., provides reference for similar highway and bridge engineering and other related types of engineering projects, and promotes the transformation of the industry to sustainable development.

At the regional development level, the project will significantly enhance Xiamen's transportation network upon completion. It will powerfully drive regional economic integration, boost industrial upgrading along the route while creating employment opportunities and fostering vibrant social development. More importantly, as a vital bridge connecting both sides of the Taiwan Strait, it plays a crucial role in promoting cross-strait exchanges and development across various fields. This infrastructure also serves as a key showcase for China's national infrastructure capabilities and a

vital link in advancing peaceful cross-strait relations, thereby laying a solid social foundation for the nation's long-term development.

4. Reference suggestions for the construction industry

Prioritize the adoption of digital and intelligent technologies in project implementation. Establish smart platforms such as BIM collaborative management systems to enable efficient collection, exchange, and sharing of multi-source heterogeneous data. This facilitates visualized and refined management across all project phases. Simultaneously, develop smart construction site systems and intelligent monitoring solutions to enhance safety management and ensure stable equipment operation.

Pay attention to ecological protection in the whole process of project planning and construction, formulate special construction, prevention, protection and emergency plans according to the ecological characteristics of the construction area, minimize the impact of the project on the ecological environment, and realize the harmonious coexistence between engineering construction and ecology.

Learn from the information management mode of smart construction site, improve the whole process standardization and digital management of labor personnel, use positioning technology such as Beidou to realize real-time positioning and distress alarm of personnel and ships, and improve the emergency management ability.

The construction unit, the construction unit and other parties shall actively participate in industry exchange activities, share the experience and achievements in ecological protection, digital and intelligent management, promote the communication and learning between different project teams, and promote the development of the construction industry towards green, intelligent and high-quality.

Fully consider the project's positioning and strategic significance by closely integrating it with regional development plans during the planning phase. Leverage comprehensive engineering benefits according to its strategic positioning. Incorporate the principles of "safety, efficiency, quality, economy, and green" throughout the project's entire life cycle. Aim to win top engineering awards while enhancing project influence and social credibility, thereby establishing a positive corporate brand image and promoting sustainable industry development.

5. Conclusions

This paper takes sustainable development as the starting point, applies relevant theoretical foundations, and uses the Project Section A1 of Xiamen Third East Channel as a case study to analyze the impact of engineering project management measures on the sustainable development of the construction industry. By introducing the effective, intelligent, and innovative measures adopted in this case, it provides relevant reference suggestions for the construction industry to accelerate its achievement of sustainable development and ensure the development momentum of relevant enterprises in the industry. Finally, the following conclusions are drawn:

In the environmental dimension, the measures taken by the project to control water pollution, noise pollution, and protect rare marine resources have effectively reduced the damage of the project to the ecological environment, realized the harmonious coexistence between the engineering project and nature, and laid an ecological foundation for the sustainable development of the industry. In the economic dimension, the application of digital and intelligent management methods—such as the BIM collaborative management platform and smart construction site system—has had a significant

impact on improving the economic benefits of the project, providing economic support for the sustainable development of the industry. In terms of comprehensive social impact, through the implementation of the aforementioned environmental and economic measures, the project has gained the trust and recognition of the public and society towards the construction industry. While driving regional development, it has also increased employment opportunities and promoted exchanges and communication across the Taiwan Strait, helping the industry achieve coordinated and sustainable development with society. This study still has certain limitations. For example, the research object is a large-scale, key enterprise project, so its reference value for small and medium-sized enterprises is limited. At the same time, for engineering projects of various enterprises, in the future, more updates and innovations of project management measures should be carried out, or more attention should be paid to laboratory-related test experiments—such as optimizing management platforms, upgrading construction equipment, and ensuring the normal operation of equipment. In general, scientific and reasonable engineering project management measures are the key factor driving the sustainable development of the construction industry.

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