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Application of Low Carbon Technology in Construction and Exploration of Carbon Emission Control Path

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ABSTRACT
As one of the main areas of energy consumption and carbon emissions, the construction industry's environmental responsibility has become increasingly prominent. The proposal of China's "double carbon" goal has further pushed the low-carbon transformation of the construction industry to a strategic height. Direct and indirect carbon emissions from mechanical operations, material transportation, temporary facilities, etc. during construction are often underestimated due to short cycle and scattered data. The contradiction between the high energy consumption, high emission characteristics of traditional construction technology and the requirements of green and low-carbon development has become increasingly prominent, and it is urgent to achieve a breakthrough through technological innovation and management optimization. Based on this, this paper explores the application of low-carbon technology and carbon emission control path in construction engineering, for reference.

KEYWORDS
Construction engineering; Low carbon technology; Application; Carbon emission control

1 Introduction

Exploring the application of low-carbon technology and carbon emission control path in the construction of construction projects will help to fill the theoretical gap of carbon emission reduction in the construction stage and provide solutions for industry practice. In today's increasingly fierce green and low-carbon competition, promoting carbon emission reduction in the construction phase is not only the embodiment of environmental responsibility, but also the inevitable choice for the high-quality development of the construction industry.

2 Analysis of carbon emission sources from construction projects

2.1 Direct emission source

The direct carbon emission in the construction phase of construction engineering mainly comes from the energy consumption at the construction site, and its emission intensity is closely related to the construction organization mode, equipment selection and operation time. As the main emission source, construction machinery, diesel driven excavators, cranes, road rollers and other heavy equipment produce a large amount of CO ɑ in earth excavation, material hoisting, foundation compaction and other links. According to the measured data, the diesel consumption of a 20 ton excavator operating continuously for 8 hours is about 120~150 liters, equivalent to 0.38~0.47 tons of carbon emissions. When temporary facilities such as shed lighting and welding equipment rely on diesel generators, the carbon emission intensity of power production per kilowatt hour can reach 0.8-1.2 kg, which is significantly higher than the power supply level of the municipal power grid. Construction personnel's commuter vehicles and acetylene combustion in field welding operations constitute direct emission sources. Especially in super large projects, the cumulative effect of such decentralized emissions can not be ignored.

2.2 Indirect emission source

The concealment of indirect emissions makes it a difficulty in construction carbon accounting. The characteristics of the supply chain require full chain tracking from the extension of the system boundary. Carbon emissions from building materials transportation are affected by transportation distance, load efficiency and vehicle type. Although prefabricated components are produced in factories, their energy consumption is still included in indirect emissions from construction. Taking precast concrete composite slabs as an example, natural gas consumption during steam curing accounts for 23% -28% of carbon emissions in their life cycle. If microwave curing technology is used, this part of emissions can be reduced by more than 40%. The construction power consumption is also a typical indirect emission. Although the on-site power consumption itself does not directly generate Co ɑ, the average carbon emission factor of the power grid makes the long-term operation of high-power equipment such as tower cranes and concrete pump trucks an invisible carbon source.

2.3 Implied carbon emissions

Implicit carbon exists in the non energy dimension of construction activities, and its delayed release characteristics increase the complexity of management and control. Construction waste treatment is a potential hotbed for methane emission. Landfill of 1 ton of construction waste produces about 15~20m ^{3} of methane annually under anaerobic conditions. The carbon emission coefficient of waste can be reduced from 48kg Co α e/ton to 12kg Co α e/ton by using mobile crusher on-site recycled aggregate. The damage of earthworks to the original carbon sink of the site is often underestimated. The excavation of bare soil will accelerate the decomposition of organic matter. The leveling operation of construction land per hectare may lead to the loss of 200~300 tons of soil carbon pool. The layered excavation and immediate coverage technology can retain more than 60% of the original carbon sink capacity. Construction noise and vibration force surrounding residents to increase the frequency of air conditioning use. Although it is difficult to quantify the carbon emissions of such derivative behaviors, they should also be taken into account in the community scale carbon footprint assessment.

3 Application of typical low carbon technology in building construction

3.1 Application of green building materials and recyclable materials

The promotion of green building materials is the main path to reduce the carbon emissions implied in building construction. Low carbon cement technology such as LC3 can reduce the CO α emissions of traditional Portland cement production by 40% by mixing 30% calcined clay and limestone, and the compressive strength still meets the requirements of c30-c50 concrete. The application of recycled aggregate can significantly relieve the ecological pressure of natural sand and stone mining. The replacement rate of recycled aggregate after crushing and screening of construction waste can reach 30% -50%. The recyclable steel structure system is outstanding in prefabricated buildings, with a high degree of standardization of its components, and the reusability rate after disassembly can reach more than 70%. Compared with the cast-in-place structure, the carbon emission in the whole life cycle can be reduced by 15% -20%. Bio based building materials such as bamboo wood composite formwork, mycelium insulation materials and other new materials have begun to enter the construction site, and their carbon negative characteristics also provide the possibility of deep emission reduction, but the engineering adaptation problem of durability still needs to be solved.

3.2 Promotion of clean energy construction equipment

The energy substitution of traditional diesel powered construction machinery is the breakthrough to reduce direct carbon emissions. Electrification and hydrogen energy have become the double main lines of technological evolution. Lithium powered excavators, forklifts and other small and medium-sized equipment have been commercially applied. Sany sy19e electric excavator has been measured and shown that the energy consumption cost of 8-hour operation is only 1/3 of that of diesel engines, and the noise is reduced by more than 50%, which is particularly suitable for construction in sensitive areas in urban areas. Hydrogen fuel cell technology shows its potential in the field of heavy machinery. Xct25fcev hydrogen crane launched by XCMG group has a range of 400 kilometers. It can run at full capacity in 10 minutes after hydrogenation, and its full cycle carbon emissions are reduced by 62% compared with diesel models. The clean energy transformation of temporary facilities has also achieved remarkable results. The photovoltaic enclosure system replaces the traditional color steel plate with cadmium telluride thin film solar panel, and the daily power generation per linear meter reaches 2.1-2.5kwh, which can meet the power demand of construction lighting and small machines and tools. The wind solar complementary microgrid system has been piloted in off grid sites such as plateau and island. In a photovoltaic power station construction project in Qinghai, the wind solar energy storage system supplies 83% of the power at the construction site, completely getting rid of the dependence on diesel generators.

3.3 Application of BIM Technology

The whole process of digital empowerment of BIM Technology from design to construction has become the nerve center for fine control of carbon footprint. In the virtual construction stage at the early stage of construction, the collision detection function of BIM can reduce the amount of rework by 30% -50%, and directly avoid material waste caused by design errors. The construction simulation module can optimize the layout of the tower crane. In terms of material management, Bim and RFID technology are combined to achieve the precise distribution of building materials such as reinforcement and formwork. After the application of a project in Guangzhou, the steel consumption rate is reduced from 4.5% to 1.2%, which is equivalent to reducing carbon emissions by 56 tons per 10000 square meters of buildings. Bim5d platform integrates progress, cost and carbon data, and can automatically generate construction carbon thermal map to help managers identify peak periods of carbon emissions and adjust machinery scheduling strategies.

3.4 Function of intelligent construction monitoring system

The integration of the Internet of things and artificial intelligence has spawned a new generation of carbon aware construction sites, making hidden emissions visible and controllable. The sensor array based on Lora network collects the data of mechanical fuel consumption and power intensity in real time. AI video analysis technology can automatically identify violations such as uncovered construction soil and mechanical idling. UAV groups also play a role in earthwork balance. Lidar can scan and generate accurate excavation and fill models. Digital twin technology goes further. The actual construction state is compared with the low-carbon target model in real time. China Zun project dynamically adjusts the concrete pouring plan through the twin system to avoid additional lighting energy consumption during night construction, saving 43 tons of carbon emissions alone.

4 Carbon emission control path

4.1 Prior control path

The prior control of carbon emissions from construction projects begins at the project planning stage, which lies in the establishment of a scientific carbon budget system and low-carbon design orientation. Carbon budget preparation should refer to the calculation standard of building carbon emissions (gb/t51366) and set reasonable carbon emission limits in combination with project type, scale and regional characteristics. For example, the carbon emission intensity of commercial complex during construction should be controlled within the range of 45-55kgco α e/m ^{2}. At the design stage, the low-carbon scheme comparison model should be adopted, and the multi-dimensional evaluation of construction technology, material selection, machinery configuration and other factors should be carried out by AHP entropy weight method. BIM Technology is introduced into site planning for virtual construction simulation to optimize earthwork balance and layout of temporary facilities. A green supply chain evaluation mechanism should be established in the material procurement process, and building materials suppliers with EPD certification should be preferred. The bidding documents of the project shall specify the technical requirements for low-carbon construction, and the carbon emission indicators shall be included in the bid evaluation system. The latest construction contract model of China Construction Eighth Engineering Bureau has set the terms of liquidated damages for excessive carbon emissions, forcing the contractor to optimize the construction organization.

4.2 Process control path

The dynamic carbon control during construction depends on the deep integration of Internet of things technology and intelligent algorithm. The establishment of a carbon monitoring system based on Lora wireless network is the basic guarantee. Through the installation of fuel consumption sensors in tower cranes, excavators and other equipment, and the deployment of weighing RFID system in the stockyard, the minute level data collection of mechanical operation, material consumption and other data is realized. The deployment of edge computing nodes can realize the localization analysis of carbon emissions. The main way is to develop a construction carbon management platform, which integrates BIM model, schedule and real-time carbon data to generate a dynamic carbon thermal map. The Guangzhou International Financial City project adjusts the construction sequence through early warning of high carbon emission processes to avoid regulatory risks caused by peak superposition. In terms of emergency carbon reduction plan, the construction team should start the priority scheduling mode of new energy equipment for heavy pollution weather, and the xiongan new area construction project achieved a single day emission reduction of 4.7 tons by using the fleet of electric muck trucks during the orange warning period.

4.3 Post evaluation path

The value of carbon efficiency assessment after completion is to guide the optimization and improvement of subsequent projects. The whole process covering the production, transportation, construction and waste treatment of building materials should be constructed, and carbon audit should be implemented at the same time. The carbon emission report should be prepared in accordance with iso14064 standard, focusing on the inspection of vulnerable items such as temporary electricity and mechanical fuel. Establish a carbon offset mechanism to reflect the responsibility. By calculating the unavoidable carbon emissions from construction, take the site greening and replanting or purchase the China certified emission reduction amount for neutralization. After the completion of the Hangzhou Asian Games Village project, 1200 trees will be replanted to form carbon sink compensation. The reward and punishment mechanism should be implemented, and the project team whose carbon emissions are above 15% of the target value will be given a special reward of 0.5% of the cost.

5 Countermeasures and suggestions

5.1 Improve the standard system of green construction technology

Building a systematic and quantifiable green construction standard system is the basic guarantee for standardizing the low-carbon transformation of the industry. At present, although the code for green construction of Building Engineering (gb/t50905) puts forward principled requirements for energy conservation and environmental protection, it lacks differentiated carbon emission quota indicators for different climate regions and project types. It is suggested to refer to the CPD mode of the European Union and set the carbon emission benchmark value at the construction stage according to the building type (residential/public/industrial) and structural form. For example, the carbon emission intensity of the frame structure residential building construction should be controlled below 35kg Co α e/m ². Special low-carbon standards should be formulated for important process links, such as "code for carbon emission calculation of prefabricated components on site installation" and "green operation guide for earthwork machinery", and the technical details should be clarified. The implementation of the standard should be supported by digital supervision tools to automatically verify the compliance of the construction scheme.

5.2 Promote the industrial application of low carbon construction technology

In view of the high purchase cost of electric construction machinery, we can learn from the subsidy policy of new energy vehicles, give value-added tax credit to construction enterprises purchasing energy efficiency equipment above level 3, and establish a regional low-carbon building materials certification and procurement platform. Industry university research cooperation should focus on common technical problems, and industrialization should break through the stability technology of hydrogen fuel cells under vibration conditions. Cultivating a team of professional low-carbon construction subcontractors is also the key to the industrialization. Shanghai Construction Engineering Group has incubated the country's first professional zero carbon construction subcontractor. Its fabricated node dry connection technology saves about 85 tons of carbon emissions from the welding process for a single project.

5.3 Establishment of carbon management capacity training mechanism for construction enterprises

Improving the quality of employees is the basis of technology implementation. It is imperative to embed the carbon management module in the qualification system. It is suggested that "calculation of construction carbon emissions" and "selection of low-carbon construction methods" should be included in the compulsory courses of continuing education for first-class constructors. Project managers should learn carbon budgeting skills. The establishment of an industrial carbon emission reduction case base is also of demonstration value. The "100 cases of green construction technology" issued by the China Construction Industry Association contains low-carbon best practices covering 23 types of work. Among them, the concrete curing carbon emission control system of China Construction Eighth Engineering Bureau based on the Internet of things has been adopted by 137 projects nationwide, reducing the carbon emission of curing steam consumption by 42000 tons.

5.4 Promote the coordinated low-carbon development of the whole industrial chain

The in-depth control of construction carbon emissions should break the information and interest barriers between all links of the industrial chain. The basis is to establish a carbon data sharing platform for building materials production, transportation and construction. The innovative business model promotes responsibility sharing. A subway project in Shanghai adopts a carbon cost sharing contract. The owner bears 40% of the incremental cost of low-carbon technology, and the construction unit recovers the remaining 60% through energy-saving income sharing. This model encourages all parties to adopt prefabricated track slab technology, reducing carbon emissions by 13000 tons compared with the cast-in-place scheme. Financial instruments can accelerate the low-carbon transformation of the industrial chain. Green credit should be extended to the field of construction equipment renewal. ICBC provides a 50 basis point lower LPR preferential loan to enterprises purchasing electric construction machinery. A private construction enterprise in Zhejiang takes this opportunity to complete the electric transformation of all earthwork equipment, reducing diesel consumption by about 480 tons per year. Regional Industrial Synergy needs to be explored. During the construction of xiong'an new area, prefabricated component plants and asphalt mixing plants within 30 kilometers are connected in series through dedicated new energy transportation channels, forming a low-carbon construction industry corridor.

6 Conclusion

At present, there is still a game between cost increment and short-term benefits in the promotion of low-carbon construction technology. The solution to the existing problems at this stage requires both market incentives under the guidance of policies and the active integration of low-carbon concepts into management by construction enterprises. With the improvement of carbon pricing mechanism and the development and application of green financial tools, China's construction is also expected to provide Chinese practice for the sustainable development of the global construction industry.

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