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An examination of green building development in China from the perspective of employees

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ABSTRACT

Although China's construction industry has seen rapid growth and expansion, it has simultaneously exhausted natural resources and obstructed initiatives aimed at fostering a more sustainable economy and society. Green buildings (GBs) are an innovative concept that may address this problem. Green buildings not only contribute to environmental conservation and energy efficiency, but they also improve quality of life by reducing administrative and operational expenses over time. Notwithstanding the achievements of GBs growth in China, there are unresolved enquiries that want clarification. This research examines the expansion of GBs in China from the perspective of construction employees, exploring their perceptions and sentiments on GBs. Employees of construction firms centered on Great Britain are questioned via a questionnaire. This audience offers a comprehensive perspective on contemporary GB development, since they are actively engaged in the design, construction, and management of GBs.
Employees of ten prominent Chinese construction companies in Shanghai, the nation's most populated city, completed a total of 200 questions. They are occupying several different work roles, including designers, engineers, sales representatives, and managers. The 20 questions include several subjects, including profiling, the current status of GBs in China, and their forecasts and recommendations for the future of GB growth. The study findings, derived from 178 valid questionnaires, indicate that construction industry workers are optimistic about the strategic objectives of GBs and possess a solid understanding of the concept and its practical implementations. Construction sector workers today encounter elevated expectations and see a significant transformation in the nature and scope of their roles due to the many changes required by the transition from traditional to sustainable structures. Maintaining compliance with the ever-evolving laws and evaluation criteria for GBs is an additional burden. Simultaneously, the construction industry must consistently modify its protocols for risk assessment, management systems, and interdepartmental coordination when executing GB projects. The Chinese government, corporate entities, and other stakeholders must collaborate to advance GBs nationwide. In the future, China's construction industry will be guided by sustainable development laws, which will undoubtedly result in green buildings.

1. Introduction

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The building industry in China is a fundamental sector that significantly impacts energy consumption and environmental degradation while generating substantial economic value for the nation. An increasing number of enterprises are contaminating the environment excessively in their quest for cheap labour and substantial profits, hence hastening urbanisation in cities. An increase in pollution and a shortage of energy supply have resulted from economic concerns taking primacy. Consequently, the construction industry has emerged as the primary polluter and contributor to global warming [1].

Dong *et al.,* [2] assert that the building sector accounts for 33% of global carbon emissions, 40% of energy consumption, 16% of water use, and 40% of raw material utilisation. Moreover, fewer than five percent of China's completed buildings are classified as energy-efficient [2]. Due to these and more factors, China has exceeded all other nations in energy consumption and carbon emissions since 2011. The construction and use of a building consume significant resources, hence substantially impacting the surrounding environment. Thus, improving the operational efficiency of the construction industry is essential for enhanced environmental and resource conservation and waste minimisation [3].

As a result, the concept of "green buildings" (GBs) has arisen. Dakwale *et al.,* [4] asserts that green buildings exhibit remarkable performance regarding functionality and environmental effect. To mitigate the building's influence on human health and the environment, this architectural concept considers the whole lifecycle effects on energy consumption and ecological sustainability from design through construction to utilisation [4]. In addition to promoting consistent development in the construction industry, green buildings mitigate environmental harm, which is essential for preserving harmony between humanity and the natural environment. Consequently, to foster economic growth, it is imperative for China, undergoing an unparalleled urbanisation process, to construct cities that prioritise green regulations, environmental safeguards, low-carbon practices, and a sustainable urban ecosystem. Consequently, the urban building complex serves as an essential conduit for the metropolis. It is essential for modern cities to prioritise the development of the green construction sector. This will mitigate the environmental consequences of overdevelopment and reduce energy expenses. In addition to enhancing a building's energy efficiency and reducing its operational and maintenance costs, green buildings may also extend the building's lifespan [5]. Besides facilitating the emergence of novel energy sources, it may promote the establishment of new energy generation and resource recycling facilities, as well as other emerging industries [6].

The development of GBs has garnered significant governmental focus from China in recent years. Yu *et al.,* [7] assert that the government has successfully fostered sustainable development in the construction industry via the implementation of many relevant legislation, procedures, and standards. Consequently, GB design, materials, construction, and maintenance have seen substantial alterations. Collaboration among different construction businesses is more essential when constructing green buildings compared to traditional structures [8]. Moreover, construction firms must adhere to more stringent restrictions concerning investment expenditures, execution protocols, project schedules, and objectives. The government's active advocacy for green buildings (GBs) has facilitated the dissemination of the idea; yet, challenges persist, including construction workers' inadequate comprehension and application of GBs, an immature regulatory framework, unequal regional growth, and insufficient green retrofitting of existing structures. The viewpoints and dispositions of construction workers towards GBs significantly affect the long-term sustainability and implementation of GBs in China, and this effect will intensify as these workers remain active in the sector. In China, GBs are seeing rapid expansion due to many targeted initiatives. The employees' lack of familiarity with GB and their insufficient management systems jeopardise the achievement of this strategic growth objective.

GBs represent the essential development trajectory that China's construction sector must embrace, serving as the inevitable choice for achieving the strategic transformation and enhancement of China's building inventory (both residential and commercial). This research reflects the perspectives of Chinese construction workers, whose work results influence the overall effectiveness of GB implementation.

1.1 The Status of China's Construction Industry

The building industry in China has had significant growth since the reform and opening-up period began in 1978. This may be ascribed to the nation's swiftly growing economy, which has heightened the need for construction and infrastructure [9]. In 1978, the construction sector exhibited a growth rate of 3.8%, which increased to 6.66% in 2010, resulting in its contribution to the global gross domestic product (GDP) rising from $268 billion to $5,926 billion in the world's second-largest economy [10]. In the next decade, China's construction industry will see unparalleled expansion. The annual total production value of China's construction industry increased from $1,491 billion in 2010 to $4,098 billion in 2020 [11]. The construction industry is crucial for national economic progress and stability.

Several notable Chinese construction projects have garnered worldwide acclaim in recent years, enhancing the nation's already impressive reputation in this domain. The Beijing Bird's Nest and the Water Cube exemplify significant architectural achievements. Goodchild [12] assert that these 'post-modern' constructions not only contest conventional architectural techniques but also alter the city's appearance. These engineering structures convey a robust sense of modernity, characterised by intricate forms, advanced design concepts, and elevated applications of science and technology. The 2010 World Expo in China advanced the nation's future sustainable urban development by exhibiting green buildings—high-tech structures with eco-friendly features—under the theme 'Better City, Better Life' [13].

The world has been astounded by the rapidity of China's construction efforts. For instance, Beijing Daxing International Airport, the largest terminal globally, was built by China in less than five years [14]. Wuhan erected the Leishenshan Battlefield Hospital in under 12 days at the peak of the Covid-19 pandemic. The field hospital, covering more than 80,000 square meters, is fully functioning [15]. China has also been making significant advancements in infrastructure development. For instance, Zhang *et al.,* [16] assert that the Qinghai-Tibet Railway now has the title of the world's longest high-altitude railway, but the Hong Kong-Zhuhai-Macao Bridge is recognised as the world's longest cross-sea bridge at this time. These megaprojects clearly indicate that China's construction industry is attaining a new level of maturity and proficiency. The number of individuals engaged in China's construction industry increased from 41.6 million in 2010 to 54.27 million in 2019 [17]. The data unequivocally illustrates that the rapid expansion of China's construction industry creates many employment opportunities, hence contributing to societal stability.

1.2 The Status of China's GBs

Green buildings (GBs) are designed to minimise or eradicate adverse effects on the environment and contribute to climate change mitigation over their whole lifespan, including design, construction, and operation [18]. The use of sustainable development concepts in the construction sector has resulted in GB. The Chinese government's 2004 plan for "energy-saving and land-saving residential buildings" inspired the concept of GB in China. In 2006, the Chinese government developed the first evaluation criteria for green buildings, termed the "Green Building Evaluation Standards." This criterion unequivocally delineated the trajectory of China's green building development [19].

Since that time, China's national strategic goals and requirements for GB development—encompassing many regulations—have been clearly evident regarding quantity, quality, and standards. Various cities use distinct subsidy incentive systems that are customised to their own geographical conditions. Over 200 Chinese cities have lately shown interest in developing eco-cities, a significant component in the development of GBs [20]. A prominent certification scheme for green buildings is Leadership in Energy and Environmental Design (LEED). The objectives are to diminish information asymmetry and to provide credible and genuine sustainability labelling for buildings [21]. By 2020, China had 6,273 LEED-certified and registered projects, with 677 situated in Shanghai, the nation's most densely populated metropolitan centre [23]. This indicates that first-tier and eastern coastal cities in China are seeing significant GB growth.

Three fundamental and unique avenues define GB activities in China: suitable green technology, intelligent systems, and materials. The primary focus of GBs technology encompasses solar heat, geothermal water, building heating, wind energy, photovoltaic cells, bioenergy, and other sustainable technologies such as radiant cooling, HVAC systems, and displacement induction devices, all aimed at minimising energy consumption and promoting renewable energy [24,25]. Yang *et al.,* [26] said that these technologies seek to enhance building operations by addressing HVAC systems, lighting, electrical appliances, and other pertinent elements. The use of prefabricated building components, designed and manufactured in a factory prior to assembly on-site, is another characteristic of GB [27]. Prefabricated construction methods are now experiencing significant popularity in China. These technologies have integrated production and assembly, conserved resources, minimised waste, and significantly reduced their impact on the building site's environment. Consequently, they may enhance energy efficiency. The primary constituents of GB materials are those used for walls, doors, windows, and decorative purposes.

The integration and analysis of all building designs using energy-efficient software on cloud computing platforms is an essential aspect of sustainable and intelligent construction. This software can optimise the whole construction process, reduce waste, and enhance productivity, yielding optimal outcomes for both the environment and clients. Smart lighting, sun visors, HVAC, and other intelligent facility management technologies are solutions peculiar to Great Britain in this domain. Chmeit *et al.,* [28] define "green BIM" (Building Information Modelling) as the integration of sensors and technology into buildings to collect and manage data during the building's whole lifecycle. This strategy seeks to attain sustainability objectives and augment overall advantages.

Recent advancements have occurred in technological measures, evaluation criteria, regulation, policy, and innovation because to the rapid expansion of China's GBs. The number of GBs in China has doubled; nonetheless, the nation remains inferior to affluent nations in terms of developmental concepts, technical strategies, regulatory frameworks, and legal systems. Although worldwide GBs have attained a significant level of advancement, China's understanding of GBs remains in its nascent phase [29]. This research examines the fundamental factors that either promote or obstruct the sustainable expansion of GBs in China.

1.3 The Role Played by the Green Construction Industry

The primary function of GBs is to enhance energy efficiency and promote environmental preservation. Lyu *et al.,* [30] assert that this will enhance the quality of life, health, and comfort of the building's residents and the surrounding region. GB techniques provide cost savings in the long term for building enterprises and professionals about use, administration, and maintenance charges. The manufacturing, shipping, installation, and assembly of raw materials constitute a substantial fraction of a building's overall energy consumption and greenhouse gas emissions [31]. Conventional construction methods use fifty percent less energy and generate fifty percent less carbon dioxide compared to alternative building methods [32]. This results in deforestation, contamination of water and air, desertification, and adverse health impacts on people. Trash and rubbish will inevitably build at each stage of development. Furthermore, GBs aim to diminish, if not eradicate, methane emissions from excessive waste and their impact on soil and groundwater, both of which constitute major environmental issues.

The life cycle of a building has four different but interrelated stages: production (design), construction, utilisation, and end-of-life. Amaral *et al.,* [33] observe that choices made during the manufacturing and construction stages substantially influence the building's energy consumption and other sustainability performance metrics over the extended operational term, rendering these phases essential for the application of green building concepts. Wang *et al.,* [34] suggest that ecological cement technology might mitigate pollution by recycling and repurposing a substantial amount of construction and municipal waste as fuel for cement and concrete production. Conventional glass structures dissipate heat, however near-infrared electrochromic windows may maintain occupant comfort while reducing energy consumption by fifty percent.

Simultaneously decreasing building energy consumption is achievable with data modelling software that models the impacts of materials and designs. An example is the capacity to do real-time building analytics and management using GB-supporting information technology models [35]. The enhancement of sustainability and environmental protection in construction may be substantially achieved by integrated design software that provides energy simulations, air quality assessments, and analyses for the reuse and recycling of construction waste [36]. The use of GBs may help reduce unnecessary energy expenditures for construction companies and occupants, which constitute the largest portion of a building's total life cycle cost [37]. Challenges arising from real-world contexts, such as excessive material consumption or detrimental solid waste pollution, may occur during the installation phase of building materials. The environmental health of building inhabitants may be adversely affected if faulty green building techniques during construction result in fungal development due to pipe leaks or moisture from water condensation [38]. Consequently, using prefabricated construction technologies may ensure efficient building processes while minimising on-site waste and pollution. Furthermore, using eco-friendly products may guarantee that they do not pollute the human body or the environment.

Numerous GBs include inherently biodegradable elements that will not adversely affect the soil and atmosphere at the end-of-life (decommissioning) phase. The GB principles advocate for the reutilization of non-biodegradable resources in the production of new building materials, hence establishing a positive feedback loop. Minimising or repurposing building materials may enhance resource and economic efficiency and diminish material waste [39]. A case study in Australia shown that reusing 80% of a building's components, such as walls, floors, and structures, may lead to a reduction of around 20 kg/m2 in yearly carbon emissions [40]. Thus, there are substantial economic and environmental benefits to promoting GBs and their associated concepts and practices across all domains of resource allocation, reorganisation, material production, utilisation, and recycling.

2. Methodology

2.1 Case Background

As GBs have only just begun to proliferate in China, a comprehensive examination of the sentiments of construction industry workers about the promotion and development of GBs in their nation has yet to be conducted. A multitude of construction firms of diverse scales operate nationally, serving the demands of first-tier cities with considerable GB prominence, like as Shanghai, an eastern coastal metropolis. The efficacy and efficiency of executing national and regional GB policies are directly influenced by the awareness and acceptance of GB concepts among the employees of these firms, as well as the operational competence of GBs.

In 2019, construction firms in Shanghai finalised projects worth 449.033 billion yuan in other provinces, contributing to a total production value of 781.265 billion yuan for the Shanghai construction sector. Thus, the construction industry is an essential component of the nation's economy owing to its robustness. Shanghai is in the forefront of the country in GB focus and development. The 'Shanghai Green Building Development Report 2019' indicates that by 2019, 726 projects including a construction area of 65,383,800 square meters had received the LEED GBs evaluation mark certification, establishing Shanghai as the national leader in green buildings.

Industrialisation in Guangdong is a primary focus for the Shanghai government as well. Since 2016, all newly erected eligible civil and industrial buildings in Shanghai are required to comply with the requirements for prefabricated constructions. The National Exhibition and Convention Centre and Shanghai Tower are two of the most renowned landmarks in Shanghai. The Shanghai Tower is situated in the core of Shanghai's Lujiazui Financial District. Acquiring the green double certification establishes it as China's first skyscraper. This structure may attain effective 'green' functionality during its life cycle due to GB-specific technologies such as turbine-based wind power production, variable air volume air conditioning, and ground source heat pump systems. Its energy usage is about 20% lower than that of comparable structures.

The National Convention and Exhibition Centre, next to the Shanghai Hongqiao Transportation Hub, is a renowned green building. It is the largest exposition complex globally, accommodating displays, seminars, offices, and hotels, among other functions. It is set to be the first large-scale green building showcase in China in 2020. The sustainable development of the Shanghai International Convention and Exhibition Centre is guaranteed by the use of distributed energy, complete LED lighting, and comprehensive utilisation of BIM technology.

Shanghai has always been at the forefront of innovative construction methods and GB standards. The Shanghai government is dedicated to advancing the creation of low-energy green buildings and furthering the energy-efficient renovation of existing structures, while also accelerating the establishment and improvement of the post-construction facilities management system for green buildings. Therefore, this survey was sent to 10 major construction firms in Shanghai to enhance its applicability and relevance. These enterprises are essential to Shanghai's economy, encompassing almost all of China via their vast product offerings and substantial transaction volumes. The personnel of these companies, positioned at the forefront of China's national GB strategy, possess a more profound understanding of the historical and contemporary context of GBs in China compared to their counterparts in second- and third-tier cities, facilitating more comprehensive and relevant research outcomes.

2.2. Data Collection

2.2.1 Questionnaire design

The questionnaire has twenty questions. The study titled "The Attitudes and Perceptions of Construction Industry Employees on the Development and Promotion of Green Buildings" in China effectively communicates the subject to the participants. The survey has three sections. The main aim is to ascertain the respondents' demographics and contact information. Subsequently, it aims to assess the current comprehension of GBs. Finally, it explores perceptions on the future developmental goals of GB. Of the twenty questions, only two are not multiple-choice. Among these, eighteen provide a single valid response, while two include either two or four correct answers. Shanghai has a much greater number of GB projects compared to other cities; thus, the replies must to be well-informed about the newest developments regarding GBs. Conversely, these corporations engage in contracts or cooperate on several projects in various places, so making the findings of this research more comprehensive and credible.

The study sample comprises individuals employed in diverse positions within the Shanghai construction industry. The many jobs, roles, and responsibilities of participants result in their understanding of green efforts and goals being influenced by their distinct experiences and perspectives. Contractors constitute the predominant segment of the analysed companies, as they are engaged in full-cycle construction for the longest duration before the application of green building (GB) practices. Construction businesses employ a greater number of individuals compared to other sectors, considering the nature of the company and the types of positions available. The selected firms include the development, construction, supply chain, design, consultancy, and supervisory sectors, along with pertinent government organisations.

The occupational split indicates that the sample include engineers, designers, construction workers, sales personnel, scientists, accountants, and managers at various levels. The responses include all aspects of the construction process, including sales, facilities management, and GB planning and design. This research lacks the opinions of stakeholders such as government officials and construction site personnel. Government officials have positional constraints, limiting accessibility and diminishing the likelihood of articulating their thoughts. The survey excludes the bulk of construction sector personnel, often referred to as labourers, due to the low average educational attainment of construction site and associated manufacturing workers. Lacking significant decision-making power, their emphasis is on executing certain tasks and responsibilities. Consequently, the sample for this research comprises decision-makers possessing a certain degree of GB knowledge. Their commitment and implementation of GBs significantly influence the GB's final results and the effectiveness of the national GB plan. The ultimate influence of GBs is seen in their attitudes, decisions, and choices about GBs.

2.2.2 Data collection via questionnaires

A total of 200 responses were collected upon the distribution of the questionnaire. To verify the accuracy of the data obtained from the questionnaires, the completion time was first assessed. The survey consists of twenty multiple-choice questions and will likely need over six minutes to complete thoroughly. Merely eleven of the two hundred responders used less than three minutes to complete the poll. The respondent may have hastily reviewed the questions or begun a response without comprehending the inquiry, resulting in a negligent completion of the questionnaire. To preserve impartiality, these responses were excluded from the data set. Examining the proximity of the replies is the second method of verification. The survey employs a defined array of answer options for four successive groups of 10 questions. Providing identical answers to many questions may arouse suspicion and is deemed an inappropriate response. Five surveys are deemed invalid due to incompleteness or absent responses. Moreover, the replies to each survey are similar. They are also invalid due to the multitude of possibilities available in the selection, rendering the probability of similarity negligible. The research and discussion are derived on a conclusive total of 178 authentic surveys.

Crucial respondent profile information is collected in the first segment. To ensure respondent privacy, it excludes any personally identifiable information (PII) and instead contains just fundamental profile details such as gender, years of experience, and job title. A total of 178 surveys were completed by males; of these, 73.03% were from construction firms focussing on sustainability; 69.63% had over three years of experience in the sector; and 60.68% were contractors. The predominant vocations, with percentages of 33.15%, 20.79%, 16.85%, and 15.17%, were engineers, designers, salesmen, and middle and senior managers, respectively. Approximately fifty percent of the poll respondents had attained some level of college education, while nearly fifty percent had obtained a bachelor's degree or above. More than eighty-five percent of survey respondents are acquainted with and endorse the guiding concepts of GBs, and over fifty percent of these individuals have participated in more than six GBs initiatives.

3 Results and Discussion

3.1 People in Different Posts Understand GBs

The survey was completed by 178 individuals, including 59 engineers, 37 designers, 30 sales personnel, and 27 middle and top management professionals. Perspectives on the most critical issues with GBs differ across individuals in different roles. The survey indicates that 30 engineers prioritise material selection, 21 designers focus on design concepts, and 10 salesmen emphasise customer experience. Among the sixteen middle and senior managers surveyed, cost is the predominant concern. Individuals in these positions possess GB insights that align with their professional requirements and anticipations. The primary obligation for implementing the designer's outputs throughout the construction of GBs in the cycle rests on engineers, mid-level managers, and senior managers. The principal duty of designers is to produce GBs that meet the standards, whereas the main aim of salespeople is to optimise the selling price of GBs.

Therefore, engineers and managers remain responsible for integrating sustainable building practices and technologies inside construction companies. Key factors for the sustained expansion of GBs in China include a major focus on holistic cost considerations and material selection. The stakeholders' overall understanding and GBs were assessed by a multiple-choice question with four potential answers. The predominant decisions are to minimising energy use, preserving land, water, and resources; safeguarding the environment; and advancing sustainable development. Efficiency is paramount for construction firms. This pertains to all facets of the project, including design, customer service, financial management, and material selection, among others. The project can attain green design, utilise sustainable materials, allocate resources judiciously, and provide customers with the requisite experience of green buildings, provided it realises savings in energy, land, water, materials, and environmental impact while adhering to national green building standards (four savings and one environmental protection). Thus, possessing enough understanding about GBs enables workers to perform their responsibilities efficiently, thus fostering the sustained development of GBs collectively.

The objective of green and sustainable development may be attained by construction firms via comprehensive management, and the implementation phase's "four savings and one environmental protection" encompasses several aspects of green building (Figure 1). The foremost aspect is the optimal use of energy, or energy conservation. The use of advanced technology that optimally harnesses renewable resources, such as solar energy, in alignment with practical building conditions may facilitate the reduction of carbon emissions and energy conservation. The second aspect is land preservation. To design the site effectively, all regions and equipment must be considered in the pre-construction estimates. The GB's environmental credentials may be enhanced by decreasing transportation expenses and waste via the use of temporary construction sites such as prefabricated housing and by repurposing equipment.

Techniques for harvesting and processing rainwater, together with water conservation management, exemplify water-saving measures. This method may preserve both resources and water. Moreover, material conservation may save construction expenses while simultaneously safeguarding the environment via the use of sustainable items and meticulous oversight of material usage rates. Mitigating dust, regulating noise, managing light pollution, and safeguarding soil are all components of environmental conservation. Utilising water cannons and trenchless buried pipe technology for sewage installation is an effective method to maintain dust-free construction sites. Structures next to highways are constructed to be shock- and soundproof by using vibration-dampening concrete during the pouring process and durable soundproof glass.

Electric welding may be conducted more effectively in the absence of a large number of individuals. In regions with high vehicular traffic, glass curtain walls that absorb significant light are less prevalent due to the light pollution they generate. Construction waste requires stringent regulation to provide effective soil protection, and the exposed soil must be vegetated at the appropriate time. The incorporation of the aforementioned GB concepts into the structure may fully satisfy employees' needs about pricing, design, materials, and customer experience.

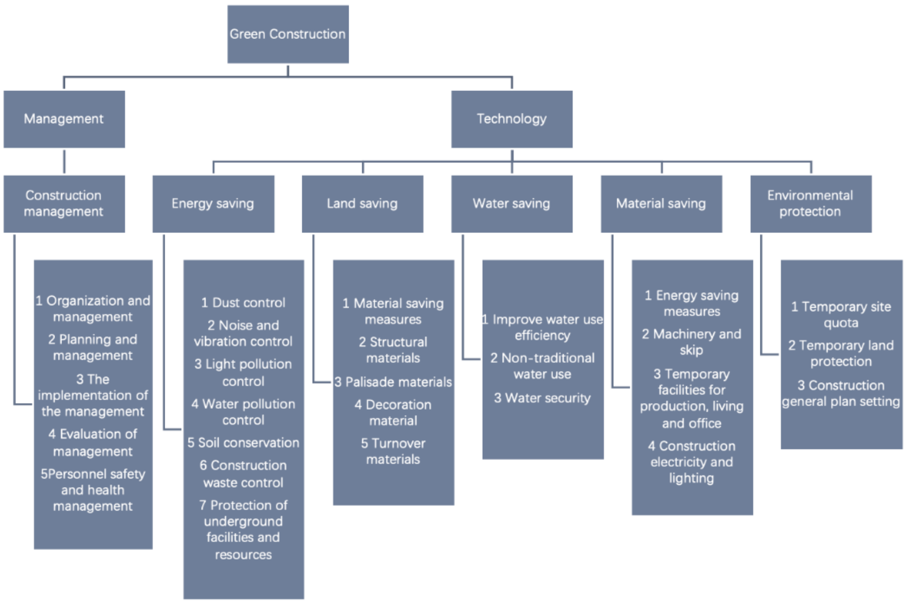

Fig. 1. Content of the GBs construction framework

Construction company workers may be guided towards specific objectives 'on the ground' by the GB concept of 'four savings and one environmental protection,' facilitating the long-term goal of sustainable development of GBs through cost reductions and resource conservation. The respondents indicate that the work requirements for the production of GBs correspond with the concept of GBs. China may accelerate its pursuit of carbon neutrality by 2060 via the sustained expansion and cooperation of various construction businesses.

3.2 The Most Popular Technologies for GBs

To provide favourable living circumstances and align with the principles of sustainable development in green ecology, GB-related technologies include construction methods that minimise emissions, save the environment, and enhance ecological integrity. According to the survey results, the use of green buildings (36.52% of respondents) is the most favoured approach to technology, following green décor materials (21.35% of respondents) and renewable energy utilisation technologies (15.17%).

Prefabricated buildings have been the subject of relevant policies published by a number of Chinese provinces and localities. Figure 2 displays the total number of policies in each province and city. While most provinces have approximately fifteen prefabricated building regulations, Shanghai's forty-five policies make it the most numerous in the province. The city of Shanghai has a regulation that states all qualifying buildings must be constructed according to prefabrication standards starting from 2016. In order to drive the growth of GBs, other first-tier cities are progressively expanding projects that need 100% prefabricated structures, and the requirements for assembly rates are also growing. Additionally, building businesses are incentivised by the fact that varied local governments' subsidy programs for prefabricated construction procedures lead to subsidies that range in quality. Particularly in first-tier cities, prefabricated structures have proven to be immensely popular and extensively used, disregarding the government's implementation standards and subsidy policies. Thus, it is clear from the survey data that prefabricated structures are a widely used and useful GB technology.

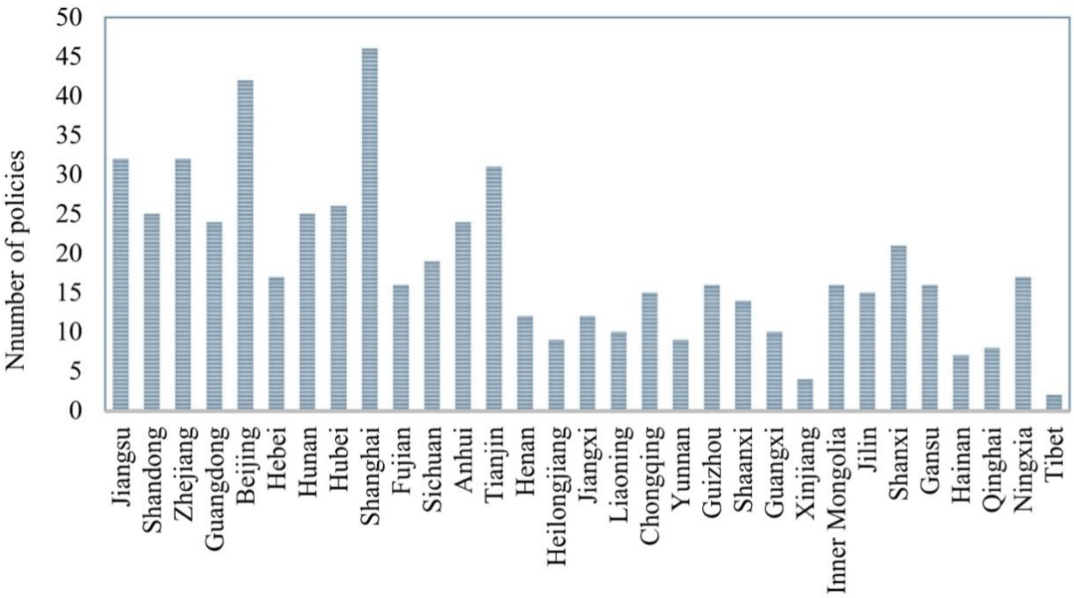

Fig. 2. Numerous provincial policies in China regarding prefabricated construction

Prefabricated structures, a key technology in China's current GB development plan, has five characteristics that enhance construction efficiency and mitigate environmental impact. The first aspect is design standardisation. The inquiry into whether building industrialisation can achieve industrialised production is essential to the discipline. Prefabrication enables architects and designers to use common blueprints. They may enhance the efficiency and aesthetics of structures by using fewer constraints and a broader array of options in architectural design and modulus configurations. Production at the facility is the second highest. Unlike traditional building techniques that depend on on-site pouring, prefabricated structures produce many components in bulk at factories. Industrialised, large-scale production techniques enhance construction workers' efficiency while reducing waste and pollution.

Building assembly constitutes the third component. Prefabricated structures function as extensive assembly workshops, installing a diverse array of components—both load-bearing and non-load-bearing—vertically and horizontally on-site. Construction companies may economise by minimising personnel count and material waste, while construction workers can gain from a safer and more efficient work environment. The inclusion of decorations is the fourth element. Prefabricated buildings enhance traditional construction processes via the integration of water and power systems, fire safety measures, aesthetic considerations, heating, ventilation, and air conditioning (HVAC), as well as features such as pre-embedded pipes and adhered exterior wall tiles. Engineers may avoid problems such as cross-working and erratic drilling in the latter stages of on-site construction by the judicious allocation of resources. The sales staff may also emphasise the quality assurance aspect of "integration of decoration" to attract purchasers. Construction enterprises may get economic and environmental benefits while aiding in the achievement of GB objectives by minimising construction durations and mitigating resource wastage. Information Technology for Management is the sixth subject. 5D virtual construction, cloud computing, and building information modelling are exemplars of information technology that have been effectively used in prefabricated constructions. Commercial establishments and households may significantly reduce management costs with comprehensive visual monitoring of the whole building lifecycle. Furthermore, the quality and safety of construction are consistently guaranteed.

Nonetheless, there are rigorous laws governing the construction, production, transportation, and assembly of prefabricated buildings. The integrity of the structure and the attainment of the GB objectives will be significantly undermined by damage or erroneous workmanship. Local governments should formulate enhanced municipal laws, construction codes, and other policies to supervise building projects. Prefabricated buildings are crucial technologies for China to achieve sustainable development in its construction industry, significantly contributing to the advancement of green buildings from the perspectives of governmental policy mandates and the support required by construction personnel.

3.3 Strengthen Familiarity with Policies and Evaluation Standards

The national and Shanghai local governments have collaboratively issued various assessment standards and rules for GBs, along with more detailed and comprehensive specifications for diverse work indicators encompassing the scope and intricacies of the tasks. Shanghai epitomises the expansion of GBs throughout China. The designated person responsible for executing specified responsibilities increasingly becomes the focal point of these regulations and their variations. The poll revealed that hardly 20% of the population is proficient in and capable of adeptly implementing the government-issued GB regulations and evaluation standards. While they comprehend the fundamentals, about 60% of the poll participants lack a thorough understanding. Concurrently, while 23.13% of respondents will actively strive to stay informed about the latest policy requirements each year, 36.76% will passively acquire knowledge of new regulations via the company's internal mechanisms, and the remainder respondents will disregard the policy changes altogether. Inadequate buildings, inefficiency, superfluous costs, and poor management may result from construction workers failing to adhere to the latest regulations, which encompass evaluation standards for green buildings, project requirements, and subsidies for sustainable technology.

The policy and assessment system are in dire need of constant updating to keep up with the ever-increasing depth of people's comprehension of GBs and the fast growth of their implementation. This necessitates that construction workers be up-to-date on these changes, comprehend them, and adeptly follow the most recent standards all through the project's lifecycle. To ensure that GBs have the greatest possible positive impact on the economy and the environment, it is essential that only certain personnel show mastery of these rules. Design professionals, for instance, may increase the number of facilities eligible for government subsidies; engineers, by enhancing engineering structures, can raise the bar for GBs; and middle and upper-level managers, by streamlining the review process, can ensure that buildings pass more quickly.

In addition to regularly modifying assessment criteria and laws to account for regional differences, the government should collaborate closely with businesses to guarantee that construction workers get enough ongoing training and education in GB-related topics. If relevant employees have a high enough level of GBs knowledge to guarantee the construction and operation of GBs to a certain extent, and if they have a nuanced understanding of the details of the work, they can help the government implement policies more efficiently. This knowledge directly impacts the construction and ultimate success of the GB strategy. In order to close the gap between China and the advanced levels shown worldwide, construction workers must also keep up a quick development pace in researching and developing GBs materials, technology, and software.

To achieve the government's strategic objectives and deliver enormous advantages to society and the enterprise, it is essential that GBs personnel be well-versed in these subjects. Their limited exposure to green initiatives may be to blame for their present state of ignorance on the policy. More interaction with green initiatives will undoubtedly familiarise GBs with the specifics of different regulations, especially given their fast growth.

3.4 Expanding Consumer Acceptance of GBs

Cost projections for constructing green buildings exceed those for conventional constructions by 5% to 15% [41]. Nevertheless, the survey's results indicate that if these workers were consumers, more than half would be willing to spend about 5% more than for conventional structures on green buildings, while over a quarter would pay 6% to 10% more. This illustrates that the majority of persons are reluctant to incur a premium cost associated with development, despite being construction workers who recognise that the investment in green buildings is more costly than that in traditional structures.

This illustrates two aspects: firstly, that the general populace does not completely comprehend the benefits of GBs and has yet to consider possible savings and environmental advantages; and secondly, that GBs have not been integrated into society via advertising and teaching. Despite a broad receptiveness to this innovative kind of building, it will need the collaborative efforts of all personnel and governmental bodies to elevate GBs to a highly sought-after product. Instead of concentrating on theoretical efficiency improvements, architects should prioritise the aesthetic design of green buildings and the strategic positioning of utilities from the consumer's viewpoint. To avoid the perception that green buildings are only a public relations strategy, sales people must demonstrate to clients how green buildings protect the environment, include aesthetically pleasing designs, and use sustainable construction materials. Consequently, the primary focus for managers transitions to identifying viable cost-reduction strategies that enable widespread consumer adoption of GBs at an affordable price point. The promotion of green buildings can only benefit the environment and construction sector if consumers are sufficiently educated on the long-term benefits of green buildings.

The government should intensify its marketing of GBs to persuade more individuals to purchase them, emphasising the significance of emission reduction, energy conservation, and environmental protection. The use of more expensive materials in the construction of GBs accounts for their higher initial cost compared to the norm, which is advantageous for builders and real estate developers. Notably, GBs have more complex building procedures and are constrained by certain material limitations. Nonetheless, GBs exhibit exceptional utilisation efficiency and may repurpose materials several times, hence reducing the danger of total capital expenditure in the future.

Simultaneously, the allocation for maintenance funds has been substantially reduced, so considerably decreasing the duration required for GBs to recover their capital. For example, regarding smart security systems, indoor ventilation devices, waste recycling systems, renewable energy, and other facilities: although the initial expenditure is considerable, the long-term advantages are significant as well. Consequently, contractors may use government subsidies to reduce the cost of green buildings, thus resulting in financial savings. Thus, all individuals may experience the many advantages of green buildings, such as enhanced health, comfort, and quality, while the green building movement can gain traction.

3.5 The Difference in Management between GBs and Traditional Buildings

In comparing green buildings to conventional structures, there are notable discrepancies in overall cost, energy efficiency, and environmental sustainability, as well as major differences among the construction firms engaged in green building projects. Regarding interdepartmental collaboration, 42.82% of respondents saw discrepancies; about the management system, 23.13% identified variances; and with respect to venture capital appraisal, 16.85% noted variations. For GBs to develop in a healthy and sustainable manner, it is imperative that construction enterprises address the difficulties that emerge during expansion.

Disparities mostly show in the extent of collaboration across various departments. The systematic nature of staff operations limits opportunities for frequent interaction and cooperation across the many departments within traditional frameworks. To achieve the objectives and requirements of GBs, continuous communication and coordination across many departments, including design, construction, and operation, is essential. This is essential since GBs must adhere to the criteria set by external entities throughout the whole process, from design to construction. This necessitates an increased need for workers' knowledge repositories and inter-company communication. A production model that integrates research and development, architectural design, technology promotion, and operational management is essential for advanced green buildings, which need active dialogue and substantial involvement from all construction personnel.

A new management paradigm has evolved. Construction businesses' technical systems and project management may increasingly transition from two-dimensional to three- and four-dimensional complexities due to the pervasive use of building information modelling (BIM) technology, which is underpinned by GBs. The efficiency of management may be substantially improved by real-time monitoring and analysis of the whole building cycle. This also fosters tighter collaboration across various divisions, perhaps resulting in ambiguity over responsibilities. Therefore, it is important for management to delineate job responsibilities clearly, and in cases of non-compliance, to facilitate the identification of the precise area of work that is deficient. Ultimately, the assessment of venture capital has evolved. Managers and accountants in the majority of organisations must consider venture capital. The risk assessment of green buildings diverges from traditional building risk evaluation due to the societal benefits being collectively enjoyed while the financial burden of construction is borne by developers and contractors. The risk assessment must include the potential extension of the construction timeline owing to the enhancement of GB construction requirements, hence jeopardising the project's timely completion. The project's short-term rate of return may decline if sales prices or rentals rise. Consequently, enterprises have heightened risks while constructing GBs for these three reasons. To promote the effective development of GBs, the company should, during risk assessments, systematically analyse its ability to invest in GBs projects.

4. Conclusion

This research employs a questionnaire consisting of 20 multiple-choice questions to examine the perceptions of construction industry workers in China on improvements in GB and their evolution throughout the years. The results indicate that construction workers are adopting and using technologies centred on GBs throughout the building of new structures and the renovation of existing ones. Simultaneously, they trust in the construction sector's capacity to attain carbon neutrality and sustainable development, which are two national strategic objectives. The public's acceptability of green buildings must be improved, and the overall standards for green buildings are far more stringent than those for conventional structures. Nonetheless, various deficiencies and obstacles persist in the present advancement of GBs, including the construction workforce's insufficient acquaintance with GBs regulations and assessment criteria. All individuals must contribute to the widespread adoption of GBs. The government should implement various subsidy and target programs to encourage the acquisition of GBs. The construction sector must enhance its management and use of GBs technology.

This research is subject to some constraints. Regional cities possess certain constraints. The results include significant limitations regarding generalisability, since the questionnaire survey only targets the first-tier city of Shanghai. The economic development in the east surpasses that of the west, and the developmental disparity across GBs is substantial, attributable to the unequal growth across various regions in China.

The geomorphology, geology, and terrain of China are distinctly different. This research suggests that the advancements in GB from the east may not apply to western China. This study aims to investigate the rise of GBs in China only from the perspective of construction industry professionals, who are substantially involved with GBs. However, limitations arise from the chosen survey demographic; the perspectives of building industry professionals cannot accurately represent the opinions of the broader populace. Finally, there are issues with the number of respondents, since the ongoing coronavirus epidemic hinders travel to more organisations for on-site questionnaire collection.

Author Contributions

The sole author was responsible for all stages of this work, including conceptualization, methodology, investigation, data analysis, and manuscript preparation.

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Conflicts of Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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