Influencing Factors of the Development of Green Building by Designers Based on Grounded Theory

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Abstract—Green building has become a trend in the development of future buildings, thereby significantly changing the general direction of building development and creating an environment for sustainable development. In this study, 40 designers were selected to conduct in-depth interviews using the grounded theory method, and the interview data were deeply extracted, resulting in four core categories, namely technology determination, personnel resources, technology management, and economic factors. This study aimed to construct a theoretical framework around the core categories and analyse their relationship, explore the influencing factors of the development of green building in China from the perspective of designers, and encourage effectively improved development of green building.

***Index Terms*—green building development, grounded theory, designers, influencing factors**

I. Introduction

With China's rapid economic development, the problems of environmental pollution and excessive energy consumption are becoming increasingly severe, and finding a sustainable development strategy for the construction industry has become a new development trend. As an important means of sustainable development of the construction industry, the green building approach has gradually matured and has become well known to the general public. In the process of promoting green buildings, there are also some prominent contradictions; for example, some green buildings have poor economic efficiency, long design and operation times, high capital cost, general running-in effect of technical input and building in the market, and long cycle of ecological benefits [1]. Designers at the core of the initial stage of the green building process, facing new technology applications and management in green building design, construction, and operation, play a crucial role in the process. The use of designers, professional skills, and catering to the industry environment constitute the influencing factors, such as guiding the development of green building.

Grounded theory is an effective method for conducting qualitative research, and is based on using empirical data to establish theories. In the early stage of a study, qualitative research methods are adopted to design and collect data, and quantitative analysis methods are used to analyse data, thereby abstracting new concepts and ideas from empirical facts [2]. Therefore, in view of the current development status of green building in China, the

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grounded theory method was applied to collect data by means of in-depth interviews. The qualitative software Nvivo12 was used as an auxiliary tool to explore the development and architecture of green building in China through in-depth interviews with designers without presupposition. Furthermore, the factors that influence the development of green building and its evaluation system in China were explored.

II. Methods and Data Collection

Grounded theory was jointly proposed by Barney G. Glaser and Anselm L. Strauss in 1967. It is based on practical observations and construction of theories by summarising concepts from original data through repeated comparison, analysis, and coding processes. Its purpose is to build theories based on empirical data [3-5]. This theory was defined by the Chinese scholar Xu Zongguo as a research method, or a 'germplasm' research style [6]. This theory was applied to collect data through in-depth interviews, and Nvivo12 was used for the coding analysis to analyse, summarise, and supplement the data to form a theoretical framework of influencing factors for the development of green building.

A. Problem Generation

Green building, as a direction of building development, is slowly getting on the right track with the support of national policies and the change ideas of people. As presented in Table I, designers play different roles in each stage of the building cycle to identify technological breakthroughs and apply new technology to create more opportunities for green buildings. It is necessary to determine the influencing factors of green building for designers and the development direction of China in the future. In this study, interviewees were interviewed in depth concerning this central issue. The interview began with the following questions. 'Have you, as a designer, been involved in the design process of green building?' 'What do you think are the requirements for designers of green building design techniques?' 'What do you know about the actual use of completed green buildings in the market?' 'Do you prefer to apply green technology to architectural design?' 'Did you feel that the design specification for green technology was improved during the design process?' Other questions were also asked, and in-depth interviews were conducted. Based on the personal design experience or feelings of the interviewees, they expressed their thoughts and subjective feelings regarding green building.

TABLE I. Flow Function of the Designers in the Process of Architectural Design

plan production	→	Designers develops the positioning of the project star level and customizes the preliminary plan.
↓		
preliminary design	→	Designers determines the technical system and determines the design details.
↓		
production of construction drawings	→	Designers simulate solutions and implement green technology on construction drawings.
↓		
identity declaration	→	Organize and declare the identification.
↓		
construction stage	→	Designers construction guidance and commissioning work.
↓		
detection stage	→	Indoor index detection.
↓		
operation stage	→	Operation team analysis and adjustment.

B. Collection and Sorting of Original Data

Before the interview, 40 interviewees were randomly selected as designers engaged in architectural design-related work in a design institute or research institute. The basic distributions of the interviewed samples are presented in Table II.

TABLE II. Basic Information of Interviewees

Classification categories	Classification basis	Amount
Gender	Male	23
	Female	17
Age	20–35 years old	19
	36–50 years old	17
	50–60 years old	4
Education	College degree and below	1
	Undergraduate	17
	Master's degree and above	22
Occupation type	Architectural designer	9
	Architectural design officer (responsible for overall planning)	6
	HVAC designer	7
	Structural designer	6

	Electrical designer	6
	Water supply designer	6

III. Data Processing

A digital voice recorder was used to record the content of the interviews, sort and summarise 40 interview materials, form 40 valid texts, and randomly select 35 samples from them as the basic materials for grounded theoretical analysis, in the process of conceptualising the data and constructing the theory. New problems still existed, and the conceptualisation process was repeated for the new problems, facilitating the process of concept extraction and theoretical construction during data analysis. The remaining five samples were tested for the saturation of the grounded theory. In this process, no new concepts or main categories appeared — that is, the theory reached saturation.

A. *Open Coding*

'Open coding' is the process of conceptualising and abstracting the original data of the in-depth interviews and utilising repeated labelling and abstracting concepts to summarise and analyse preliminary concepts and categories. The specific procedures are 1) coding and labelling the interview data sentence by sentence, 2) conceptualising the preliminary generated text, and 3) categorising the result of conceptualisation. This complete process involves analysing, refining, summarising, and integrating interview data, exploring the original data, and identifying problems [7]. Repeating this coding process, 766 labels were created, 99 concepts were formed, and 20 categories were refined. Table II provides examples of coding, conceptualisation, and categories, and Table III provides examples of labelling, conceptualisation, and categories.

TABLE III. Interview Material Text And Labelling Examples (Partial Content)

Interview data text (partial)	Label
Interviewee A: "Working on actual projects, I found that when I had just graduated from University, there were still few opportunities to get in touch with green technology, including the designer friends around me. The technical requirements of this thing are relatively strong, and the cost of learning is also high. The professionalism (requirements) for us is relatively strict. You have to consider energy saving, materials, insulation, etc., because when you practice it in construction projects, it is necessary to consider its effect, and it will directly affect the quality of the building. Besides, now this market needs this kind of technology update, which forces us to learn to use green technology, and now the country has begun some mandatory requirements in terms of energy saving. The application process of green technology itself is complicated. There are still some problems in the detailed rules of the actual use effect in the later operation of the construction industry in the construction market of our country, which makes the rationality of the design and the cooperation between the various disciplines very important. However, once blindly pursuing and using this technology, it may cause certain waste and loss..."	Green buildings have high technical requirements for designers. The technology itself has a certain degree of complexity. It may cause waste and loss. There are certain problems in the detailed rules of the actual use effect in the later operation.
Interviewee B: "In the days to come, the government will vigorously promote green building, but there is still a lack of regulatory verification methods. There are also some problems in these existing cases. Some developers should avoid certification for the sake of their immediate interests. Another concept of green environmental protection has not been deeply rooted in the hearts of the people and has not realised the benefits of green buildings. Consumers have not yet formed the habit of paying for it. Therefore, we told our customers that some of them do not approve of green buildings and feel that it costs money. The green building itself also requires practitioners to have a certain knowledge reserve in cross-fields, which also increases the difficulty of green design. Before you do a type of project like this, you should check some information. The basic statistical research and related databases at the national level are complicated and the ecological footprint is difficult to calculate. These are all necessary preparations before doing the project..."	The concept of green environmental protection needs to be popularised by all people. Professional cross-field technical personnel are needed. The calculation of the data in the national database is complicated.
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As presented in Table IV, the interview materials, such as 'strong technology of green building design' and 'large learning cost', are labelled a1–a3, during the analysis of the specific contents of the interview. Conceptualised from this type of label concept, it can be concluded that 'aa1 green technology is difficult'. This concept is classified into the same category as other concepts with the same attributes, and the category with similar concept is labelled as 'A technology applications'.

TABLE IV. Open Coding of Interview Data on Influencing Factors of Green Building Development for Designers

Interview data	a Label	Aa Conceptualization	A Category
Green building design is more technical	a1 strong technical	aa1 Green technology is difficult	A1 technology applications
High learning cost			

Integration with traditional techniques needs to be improved	a2 There are differences or contradictions in the application procedures of other technologies		
Not many relevant technical staff	a3 technical support		
Inadequate matching of technical reserves and capabilities			
......			
Many aspects need to be considered in the full cycle of green technology	a49 Many processes involved	aa9 process involved	A2 Technologie-s updation
The organization's own reform and innovation use of new technology is not strong	a50 Technology is not innovative	aa10 Technical process inertial thinking	
Have a certain misunderstanding of green building technology			
The market technology demand is not strong			
......	......		
......			
pressure factors	a67 New technology is difficult	aa17 Certain resistance to technology application	A3 technical complexity
Inertial Thinking about Traditional Design			
Acceptance of new technology uptake			
Individual differences in technology applications	a68 Accept the differences of new technologies		
Complex transition process of design process			
Process transformation of the practical application process	a69 Difficulty of pattern change	aa18 mode transformation	
Process transformation of the technology management process			
......			......

B. Associative Coding

This is a process of constructing the core category of grounded theory through keyword search, repeatedly studying and reasoning open coding, constantly summarising and discriminating, and further refining and conceptualising these codes. It was found that 'A1 technology applications', 'A2 technologies update', 'A3 technical complexity' and 'A4 inertia thinking of technical processes' are related to the core category of 'AA1 technology determination' in the coding process. This code can reflect the cognition of most visitors on green building and its design; thus, this concept is determined to be the core category of 'Aa1 technique determination'. In the process of categorisation, which seeks for a 'core concept' and the generic concept constantly expanding around it, and classifies, separates, and summarises the process to obtain the core category building the theory construction [7]. This study used the above theory construction to repeat the initial interview data, obtaining the four core categories, 'AA1 technology determination', 'AA2 personnel resources', 'AA3technology management', and 'AA4 economic factors'. As shown in Table V, the core relationships are obtained by coding a series of related logical models.

TABLE V. RELATION OF FOUR CORE CATEGORIES

Core relationship	Core categories	Category meaning
Conditional factors	AA1 technology determination	Green technology covers the overall planning of each link, affecting the final presentation of the design.
Organisational relationship	AA2 personnel resources	There is some resistance in the application of technicians.
Impact	AA3 technology management	It implies technical management and application execution, considering the difficulty of combination with traditional techniques.
Consequence	AA4 economic factors	Technology application and cost–performance ratio of investment.

C. Selective Coding

Selective coding is the process of extraction and classification from core coding. In this stage, the relationship between the identified core categories is explored. The categories are coded, and the theoretical framework is constructed. In the interview process, four core categories — 'technical determination', 'personnel resources', 'technology management', and 'economic factors' — emerged around the central question of 'designers' influence factors on green building'. Among them, 'AA1 technical determination' was supported by 4 categories, 28 conceptualisations, and 157 labels. The core category 'AA2 personnel resources' was supported by 4 categories, 16 conceptualisations, and 102 labels. The core category 'AA3 technology management' was supported by 4 categories, 19 conceptualisations, and 161 labels. The core category 'AA4 economic factors' was supported by 4 categories, 15 conceptualisations, and 125 labels.

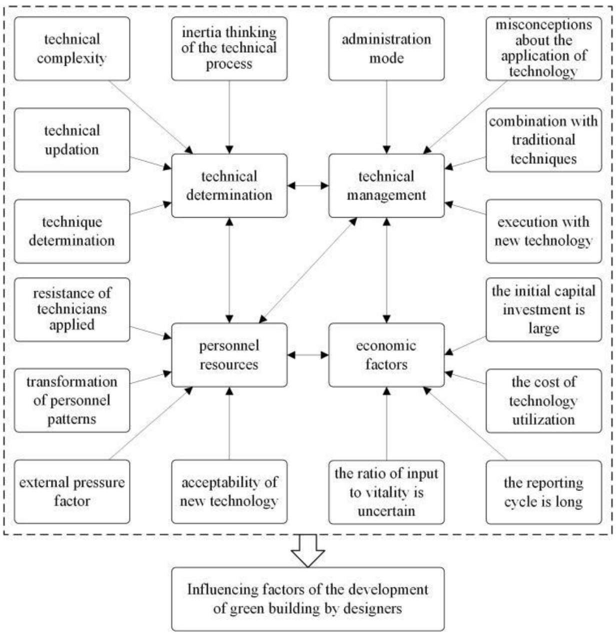

Figure 1. Interview data correlation coding

Through repeated data coding, the five reserved interview data were repeated in the process of theoretical sampling coding, and a theoretical saturation test was performed. The absence of new core categories in the main category indicated that the four core categories mentioned above reached a saturation state after selective coding. Fig. 1 illustrates the correlation coding diagram.

IV. THEORY CONSTRUCTION

Through the above coding process, four saturated core codes were obtained. Based on the qualitative and quantitative analyses methods, the influencing factors resulting from the technical determination, personnel resources, technical standards, technical management, and economic factors identified in the development of green building were determined from the perspective of designers. As depicted in Fig. 2, the theoretical framework of the influencing factors of green building development was constructed, and core coding was evaluated to make the theory more scientific and rigorous.

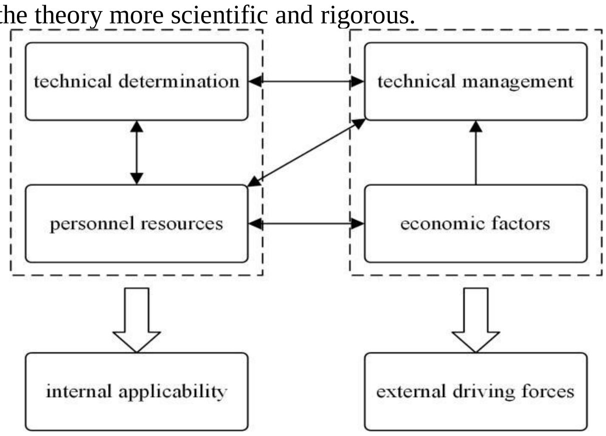

Figure 2. Theoretical framework of influencing factors of green building development

A. Technical Determination

With the upgradation of complex technologies in the construction market, traditional architectural design has been unable to fully meet the needs of various groups of people for buildings. The application of green building technology is a comprehensive and complex, continuous process of practical technology application, including the application of building materials, building structures, and other interdisciplinary disciplines. The technical determination affects the comprehensive effect of the design progress, quality, and application of the building. Designers play a critical role in promoting the entire design process. Factors such as technology application, technology update, technology complexity, and technology process comprehensively affect every stage of the entire life cycle of building application projects. Therefore, the determination of green technology is of great significance for future decision making and the development of green buildings.

B. Personnel Resources

From traditional architectural design to green architectural design, architects must meet the needs of the market and fill the knowledge gaps in the application of new technologies. Variations in architect feedback on the application of new technologies also affect the effectiveness of the actual application of buildings. In the application process of green buildings and their technology, the development of green buildings in some areas is hindered because of the difficulty faced by designers in the practical application of green technology and the unfamiliarity and imperfection of the combination of technologies. The lack of motivation for technology application is also the main factor hindering the development of green buildings.

C. Technology Management

In the promotion of green building technology, there is a significant amount of information in the entire life cycle of a building project. In addition to technology application, technology management also involves the coordination of processes, time nodes, and other management aspects. The lack of control over technology management due to new technologies creates some obstacles for architects. According to the general design of the initial target, in the process of the management of a green building, the management of designers in the organisation, coordination of the products, design, management, operation, debugging, and process must be undertaken to control the entire project and estimate the cost of a suitable energy-saving goal. This would cause the building products to achieve optimal control of each detail; therefore, the technical management must undertake the project and control the positive direction of the key elements.

D. Economic Factors

The economy of green building is one of the important factors affecting its development. The practical application of green building can obtain an appropriate economic cost by determining an appropriate design scheme through suitable technology utilisation. It can also result in a better profit return in terms of energy consumption, environmental impact, and other aspects to provide better feedback to the building project itself. When designers use green technology to improve the design quality and the corresponding design cost, it is necessary to determine the optimal economic scheme. Therefore, designers should consider the economic cost of applying green technology to building design, which is also a long-term consideration for achieving an efficient return on investment.

V. Discussion

From the perspective of intrinsic applicability, designers play a crucial role in promoting the application of green technology, which are comparable to ‘initiators’ and ‘boosters’. Green technology is a complex and full-cycle comprehensive technology. Although it needs an overall design from the designers, it affects every stage of the entire life cycle of the entire construction project and plays a pivotal role in all other units throughout the entire life cycle.

In the implementation of green building projects, the external driving force is also an important factor affecting its development. If a comprehensive technology cannot be better managed and organised in the process of popularisation and application, there will be a negative effect on designers. This may lead to more negative effects in the future. Because of the influence of external factors, such as the technical level, development, and promotion of green technology, in domestic building applications and management and operation research, the application effect of green technology in building projects still has some room for running-in. This influence is reflected in the proportion of energy efficiency of building projects, economic returns, and benefits.

Starting from the in-depth analysis of grounded theory, four core categories were obtained from the perspective of designers, their core relations were analysed, and the influencing factors of green building development were examined from the two macro directions of internal applicability and external driving force to provide a reference for the development strategy of green buildings.

VI. Conclusion

By conducting in-depth interviews with designers, combined with the substantive coding process and analysis of the emerging core codes, a framework was constructed for discussing the factors influencing the development of green buildings from the perspective of architects. The root causes were explored from the aspects of technology determination, personnel resources, technical roots, technical management, and economic factors. The development of green building requires internal applicability and external driving force, which are interrelated and mutually influential. Therefore, better application of green technology in construction projects must be initiated through the internal technical applicability, while considering the influence of external driving forces, to seek a better direction to adapt to the development of green building in China.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization, Ying Z., J.K., H.J. and Yan Z.; methodology, Ying Z. and J.K.; validation, Yan Z.; formal analysis, Ying Z.; investigation, Ying Z.; resources, Ying Z.; data curation, Ying Z.; writing—original draft preparation, Ying Z.; writing—review and editing, Ying Z., J.K., H.J. and Yan Z. All authors had approved the final version.

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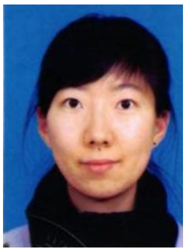

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