Designing and Explaining the Combined Model of Building Information Modeling: Grounded Theory AND Sustainable Development

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Abstract: The method used in this research is foundational data theory due to the exploratory nature of the research. The main basis for collecting information is to conduct in-depth interviews with experts, professors, and experts of construction projects of the municipality of the 3rd district of Tehran, in total 15 interviews were conducted from the collection of information, and the codes related to the written interviews have been analyzed. The findings of the research, after performing the three steps of open, central, and selective coding, led to the presentation of the final model of the research, where the codes collected from the interviews were categorized into 55 concepts and 14 main categories. The results of the research showed that the categories of environmental and causal factors affecting building information modeling and the categories of optimal building design, integration of contractual models and sustainable development, conservation of natural resources, development and training in structural categories, management factors, and Information technology in the intervening categories and infrastructural, organizational and macro consequences have a significant impact on the sustainable development of the construction industry.

Keywords: Building Information Modeling, Sustainable Development, Grounded Theory, SEM

INTRODUCTION

The building has been considered a capital good for a long time and an important part of the family's property has been invested in this sector, in such a way that it has attracted large capital from different sectors of the economy (Heydari Khalaf Badam & Barmayehvar, 2022). Countries around the world consider the construction industry as the main driver of their economic growth and development (Okoye et al. 2018). This has caused an unprincipled boom in construction, especially in the construction industry, which has caused many problems (including the low quality of buildings, the short useful life of buildings, the production of excessive construction waste, the inability to recycle construction materials, etc.....) It has led to excessive consumption of natural resources and irreparable damage to the environment (Shaker, 2017). In general, the rapid growth of urbanization, the creation of towns and residential complexes, and the astonishing expansion of megacities have caused asymmetric development in different dimensions, the result of which is the lack of attention to the principles of sustainability in construction, especially in the construction industry, which results in losses. Bari will follow (Sultan & Alaghbari, 2023). On the other hand, the construction industry plays an important role in the development and prosperity of society. It is one of the leading sectors for job creation and distribution of wealth among the people. However, the characteristics of this industry are not in favor of its sustainability because it has unique characteristics such as multi-layered, dynamic, scalable, multi-disciplinary, fragmented, complex, and unstable (Gamil et al. 2020).

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Sustainable construction is a new approach that has recently received much attention due to its effects on the management of construction projects. Sustainable construction is not only creating a building that has little adverse effects on the environment and is compatible with it; Rather, it is a new approach in the construction sector that also improves people's way of life (Teng et al., 2022). Alternative technologies such as building information modeling are among the recent building development technologies that have had a significant impact on increasing the optimal performance and making the construction system efficient. Combining the use of new technologies in the life cycle stages of the building with the concepts of sustainable development will improve the sustainability index in the construction process (Sanchez et al., 2020). From the concept of sustainability, various definitions have been presented so far: "providing our own needs without destroying the ability of future generations to meet their needs", "living well within the limits of nature" and... (Solaimani & Sedighi, 2020). The meaning of sustainability in the construction industry is not to build structures that are only resistant to stresses, but it means that the structure takes into account the current environmental conditions and tries to meet its needs based on them (Heydari Khalaf Badam & Barmayehvar, 2022). Regardless of the different definitions of sustainability, experts consider this concept to have three major domains, namely economic, social, and environmental, and they believe that instead of giving value to one of these three dimensions, sustainability aims to optimize all three so that the economy of countries in in the long run, don't pay the costs of not being sustainable (Goel, Ganesh & Kaur, 2019). In this regard, the process of sustainable development, with the strategy of adapting resources to current and future needs, provides solutions for the development of structural, social, and economic models to prevent issues such as the destruction of natural resources, the destruction of biological systems, and pollution. , climate change, excessive population increase, injustice, and lowering of the quality of life of present and future people should be prevented (Huemann & Silvius, 2017). Based on this, sustainability assessment is an important tool that can help managers and policymakers make decisions in an effort to create a more sustainable society (Kivila, Martinsuo & Vuorinen, 2017).

The demand for sustainable construction in the 21st century is increasing primarily to solve irresponsible environmental problems that cause unlivable, unmaintainable, unrepairable, unsafe, and unsustainable buildings (Fadeyi, 2017). Innovation in science and technology plays an important role in supporting the progress towards sustainable development, especially clean production and functional process (Chong & Wang, 2016). Building information modeling represents how the building is designed and constructed and can also facilitate multi-stakeholder coordination and integrate and integrate 3D designs, analyses, and cost and schedule estimates (McArthur, 2015). Building information modeling can help to reduce the environmental, economic, and social effects of construction, such as achieving sustainable energy use, optimization, accurate timing and cost reduction, and increasing safety in construction (Chen et al., 2018). Building information modeling is a powerful tool that allows the user to have a visual simulation of the project and be able to view its virtuality before building the sample. Although this process requires training (Saieg et al., 2018). There is a significant potential in the BIM methodology that can increase the quality and efficiency of the entire construction and operation process. Instead of working with parallel execution programs and the time spent to fix them, each person can access databases and make changes in real-time (Hall et al., 2022). Changing the approach to building information modeling is valuable on many levels. This will lead to greater transparency, communication, financial security, and better planning for construction projects. Building information modeling as one of the intelligent technologies available for the construction industry with visualization can help facilitate the performance among the project stakeholders (Olawumi & Chan, 2019).

The application of BIM started in 2002 in the United States and by 2007 it had grown by 25% and by 2015 it had grown by 80%. The European Union has also advised builders and developers of construction works to implement the BIM system since 2017, which shows the importance of the issue and the ability of this system to implement large and complex construction projects; Therefore, in this context and in terms of the importance of quality and comprehensive construction, it has been tried to use this system as a practical tool in the construction industry by implementing sustainable development in BIM (Ningappa, 2011).

In the research conducted by Raut et al. (2018), it is pointed out the need for a comprehensive framework that can evaluate three sustainability indicators during the implementation of the project. The use of building information modeling technology during the construction and implementation stages of the project can accelerate the achievement of buildings that comply with sustainability factors and, as a result, sustainable cities (Olawumi & Chan, 2019). Building information modeling allows different stakeholders of the project to manage the digital data of the building during its entire life cycle (Cavalliere et al., 2019). Recent studies have shown that building information modeling from energy demand simulation and environmental impact assessment over the building life cycle, which is an effective method for considering scenarios for reducing gas emissions related to material processing and construction methods, supports (Yuan & Yuan, 2011).

In recent years, research in the field of building information modeling and sustainability studies has increased. However, only a few studies have been conducted with the approach of trying to investigate the integration of building information modeling technologies to strengthen the implementation of sustainability methods in the construction industry (Olawumi & Chan, 2019). Building information modeling technology is one of the methods that, due to the possibility of creating strong databases for the building and its components, as well as creating and providing rich information IDs for them, it is possible to make optimal decisions for the implementation of projects at any stage of carrying out the project has significantly reduced the time and cost of executive management and construction. Building information modeling technology, as a powerful tool in the hands of managers, improves project success criteria, criteria such as cost, time, and quality. Several studies have also been presented by experts. Haruna et al. (2020), conducted research on building information modeling programs for sustainable building development (multi-criteria decision-making approach). More attention was paid to building information modeling (BIM) and multi-criteria decision-making (MCDM) globally due to their advantages for different phases of the building life cycle. The purpose of this article is to improve doctors' understanding of the process of accepting building information modeling and multi-criteria decision-making toward sustainable construction through energy efficiency. A questionnaire survey is being conducted for construction professionals and construction industry experts in Malaysia. With expert survey data, a multi-criteria decision-making model was constructed using an analytic network process (ANP) to identify the main factors influencing sustainable building by reducing embodied and operational energy and carbon emissions. The data of this survey was analyzed using descriptive statistics. The developed model includes three clusters with a total of six nodes, and the significance levels are compared pairwise. The results show that optimizing the design, and reducing the need for materials is one of the important factors for sustainable construction, which is considered in the building information modeling program. Olawumi & Chan, 2019 conducted research on critical success factors for implementing building information modeling and sustainability practices in construction projects. The purpose of this research study is to investigate and evaluate critical success factors (CSFs) that can enhance the integration of building information modeling (BIM) and sustainability practices in construction projects. The key drivers identified in this study are people-oriented, and data- and technology-driven interventions in the built environment. Basic deductions were formed based on the comparative analysis of expert groups. The findings of this study have provided valuable lessons for local authorities, policymakers, and project stakeholders to motivate the full implementation of green building information modeling initiatives. This study has also provided important recommendations to increase the uptake of building information modeling and sustainability methods in the construction industry and has contributed to existing knowledge on smart urbanism and practical practice in the built environment. Zhang et al. (2019), conducted research on the limitations of building information modeling (BIM) programs for sustainable building projects. China's construction industry has faced significant challenges in achieving sustainable development and digital operations. Combining building information modeling and sustainable construction is a good way to achieve these goals. However, obstacles affect the applications of building information modeling technology in sustainable buildings, resulting in significant cost and time loss. Likewise, it is important to identify the limitations preventing the application of building information modeling technology in sustainable buildings. This study used the method of factor analysis, exploratory factor analysis (EFA), and structural equation modeling (SEM) to investigate the key limitations and conducted a questionnaire with 389 respondents to investigate the applications of building information modeling technology in sustainable construction projects. have given. The results showed that there are four main limiting factors: "Public participation", "Technology application", "Economic cost" and "Local management and the private sector provide and therefore can improve the implementation of building information modeling technology in sustainable buildings. and contribute to the realization of China's sustainable development goals. Reizgevičius et al (2018), conducted research on the topic of promoting sustainability through investment in building information modeling (BIM) technologies. The purpose of this article is to increase the understanding of how design companies understand the benefits of using building information modeling technologies. Building information modeling has been recognized in the literature as a (potential) powerful driver that moves the construction sector towards sustainability. However, for design firms, the choice to invest in building information modeling technologies is primarily an economic one. In particular, a design firm evaluates economic benefits and efficiency improvements thanks to the use of building information modeling technologies. This paper discusses the return on investment (ROI) in building information modeling technologies and reviews the ROI calculation methods presented by other authors. In order to properly evaluate the return on investment of building information modeling, practical calculations of return on investment have been made. Appropriate methods, along with relevant variables, have been developed to calculate ROI. This study provides the possibility to adjust the calculation method to be more accurate and understandable using Autodesk Revit-based ROI calculation. Fadeyi (2017), conducted research on the role of building information modeling (BIM) in providing the sustainable value of the building. The value of a sustainable building is the quality of the building performance provided to solve the problems of the consumers - developers, owners, and users of the building - within the time and cost constraints of the resources used to provide quality. Delivering functional, environmentally friendly, and livable buildings that can be maintained and operated with ease, safety, and security solves the problems of consumers. The problem of delivering sustainable building value to consumers is due to multiple building delivery professionals working in silos. This paper discusses the role of building information modeling in reducing fragmentation among professionals at each stage and across building delivery phases using evidence from the literature. It is clear from the literature that building information modeling provides a virtual repository that allows easy access and sharing of information and knowledge in real-time. Thus, Building Information Modeling provides a platform for professionals to work in an integrated environment at every stage of the building delivery process. However, maximizing the benefits of building information modeling through a virtual repository depends on how the building is contracted for delivery. Identifying the knowledge gained and gaps in the literature led to suggestions for future research directions needed to improve the delivery of sustainable building value to consumers. Juan et al (2017) investigated the adoption and assessment of BIM readiness in Taiwanese architecture firms. Building Information Modeling (BIM) has gained recognition in the Architecture, Engineering, and Construction (AEC) industry because it can potentially reduce costs and delivery times. Considering the benefits of BIM adoption, the Taiwanese government intends to adopt a policy to establish BIM-based electronic exchange in Taiwan's construction permit review process. However, the effects of BIM application are unpredictable. BIM The results showed that almost every share of the surveyed companies had BIM-based tools at their disposal. More than half of the companies were willing to use BIM tools to facilitate the construction permit inspection process. However, their willingness was strongly influenced by government policies, competitor motivation, financial incentives, and technical support. Challenges, problems, and opportunities related to BIM adoption were discussed. For companies in other countries facing similar conditions and similar challenges, the lessons learned from the experiences of Taiwanese companies may be useful. Chong & Wang (2016) conducted research on the perspective of building information modeling for sustainable development. Along with the evolution of human needs, information technologies, and natural environments require a broader perspective of sustainable development, especially when considering the built environment that affects the central ecological system. The objectives of the article are (a) to review the status and development of Building Information Modeling (BIM) in relation to sustainable development in the built environment and (b) to formulate a future vision framework that promotes Building Information Modeling in sustainable development. Seven areas of sustainability were classified for the analysis of forty-four building information modeling guidelines and standards. This review examines the use of building information modeling in sustainable development, primarily focusing on some areas of sustainability such as project development, design, and construction. The developed framework describes the need for multidisciplinary collaboration to adopt the future and use of building information modeling for sustainable development. It also considers the integration between "building information modeling and green assessment criteria". and "Building Information Modeling and Renewable Energy" to address deficiencies in standards and guidelines. In other research, the following can be mentioned: Taghipour et al(2016) studied The impact of ICT on knowledge sharing obstacles in knowledge management process (including case-study). Mohammadi et al (2021) studied "Investigating the role and impact of using ICT tools on evaluating the performance of service organizations. Taghipour (2023) studied A review of the sustainability indicators' application in vehicle routing problem. Taghipour et al(2016) studied " Assessment of the Relationship Between Knowledge Management Implementation and Managers Skills (Case Study: Reezmoj System Company in Iran)". Taghipour et al (2015) studied "Evaluation of the effective variables of the value engineering in services. Taghipour et al (2020) studied Project Planning and Control System in Multi-project Organizations under Fuzzy Data Approach Considering Resource Constraints(Case Study: Wind Tunnel Construction Project. Taghipour et al (2015) studied Implementation of software-efficient DES Algorithm. Taghipour et al (2015) studied "Risk analysis in the management of urban construction projects from the perspective of the employer and the contractor."

Therefore, the research question is raised as follows:

What is the combined model of building information modeling and foundational data theory to promote sustainable development indicators of the construction industry?

METHODOLOGY

The current research, which seeks to identify the dimensions and components effective on the sustainable development of the construction industry based on building information modeling in the construction industry, is considered fundamental-applied research, and in terms of the method of data collection, it is also in the category of non-experimental research. Takes. The qualitative research method was used to answer the research problem and develop the model, and specifically, the systematic foundation data method was used to construct the theory, and structural equation modeling was used to confirm the model. The foundation data theory is derived from the data that have been systematically collected and analyzed during the research process. The foundation data method is a systematic and qualitative method that describes an action, process, or reaction about a real issue at the conceptual level (Creswell, 2007). With this method, the researcher or researchers will be able to defend and explain how to conduct the research and achieve its results. Glasser and Strauss called this research method grounded theory. The qualitative research method is the best method to discover people's perceptions and understanding of their experiences. In this method, the role of the researcher in the process of data collection and analysis is essential. The statistical population of this research includes academic experts and professors in the subject area of the research and experts of municipal construction projects in the 3rd district of Tehran, and the theoretical sampling method was used for sampling (Table 1) (Creswell, 2007). In theoretical sampling based on the researcher's theoretical sensitivity, in-depth interviews with experts go to the point where it reaches theoretical saturation.

Table 1. The number of sample members separately

Data Type	N
Exclusive interviews with academic experts	8
Exclusive interviews with experts in the construction industry	7

Research findings in the current research, data was collected through face-to-face interviews with experts, and in-depth interviews were also used as the main data collection tool. Interviewing experts means interviewing people who are influential, famous, and knowledgeable in their field of work. In this research, in the quantitative part of the research, a questionnaire with 55 questions was designed, and the information from these questionnaires was entered into SPSS 23 software for data analysis. In this way, the modeling of the structural equations of design research and the relationships between the variables were investigated and tested. The main framework of the research questions based on the data theory of the foundation is as follows:

- Why do you think the construction industry should have building information modeling?
- In your opinion, what are the most important factors affecting the sustainable development of the construction industry? Analyze it?
- In your opinion, what are the results, consequences, and effects of the design of the sustainable development model of the construction industry? (What effect does it have on the existing conditions of the industry?)
- What are the conditions, facilities, infrastructures, requirements, and platforms necessary to implement a suitable model to promote sustainable development indicators in the construction industry?
- What is the difference between sustainable development indicators in the construction industry and other industries?
- In your opinion, what are the effective environmental opportunities and threats of explaining the combined model of building information modeling and foundational data theory to promote sustainable development indicators in the construction industry? Analyze each of them, how and to what extent do they play a role?
- In your opinion, what are the organizational strengths and weaknesses affecting the design of the combined model of building information modeling and foundation data theory to promote sustainable development indicators in the construction industry? Analyze each of them, how and to what extent do they play a role?

The qualitative part of the interview was used to collect the data for this research. All the interviews were recorded and the audio file was fully implemented. Theoretical saturation was achieved in the last two interviews, but the interviews were conducted to ensure data sufficiency. In each interview, the purpose of the research and the interview process are explained to the interviewee. Both closed and open questions were used during the interview process. In this research, to find the desired information, an attempt has been made to conduct in-depth interviews and ask the interviewee to provide all the components of the foundation data theory-based approach in providing a model or design and explain building information modeling and foundation data theory for promotion. Narrate the sustainable development indicators of the construction industry in full. The analysis of these samples has been done step by step after the end of each interview. After conducting the interview, its written version was typed and after conceptualization in each interview, more key points and categories were extracted little by little.

ANALYSIS

Open Coding

Part of the research analysis is the use of open coding. After the completion of the interviews, the process of open coding begins, the codes of the interviews conducted with 15 experts and specialists were extracted during open coding, and in the next step, these common codes, along with the important codes from the researcher's point of view, were used as codes. The final ones were determined. For accurate classification of concepts between categories, each concept should be conceptualized after separating the labeled and raw data by carefully examining the text of the interviews and background notes.

Axial Coding

Axial coding links categories and subcategories with each other according to their dimensions and characteristics. Analytical tools of Strauss and Corbin were used to discover how the categories are related to each other. The main tools of this analytical tool include conditions, actions, reactions and consequences.

Causal Conditions

In this model, Causal Conditions are events that create situations and issues related to a phenomenon and explain why and how people and groups respond in certain ways. Causal conditions include cases of categories that directly affect sustainable development in the construction industry, or these factors create and develop the phenomenon in a way. In this research, three categories of environmental factors, technological factors, and environmental factors are causal factors that affect sustainable development in the construction industry. The categories related to Causal Conditions are shown in Table 2.

Table 2. Categories and concepts related to Causal Conditions

Categories	Concepts
Environmental factors	• Attention to environmental issues • Solving environmental problems • Improving sustainability indicators in the construction process • Reducing the project management process
Technological factors	• Use of new technologies • The existence of an integrated framework based on building information modeling • Reducing the project management process • Ability to make optimal decisions for the implementation of projects
External factors	• Making the construction system efficient • Create a strong database for the building • The existence of an innovative sustainable development system in the field of construction

Contextual Conditions

Contextual conditions represent a specific set of characteristics related to the phenomenon, which generally refers to the place of events and related events. Contextual characteristics include factors without which the realization of sustainable development for the construction industry is not possible and provide the context of special conditions, in which strategies are made to manage, control and respond to the phenomenon. These conditions are made up of a set of concepts, categories and background variables. In this research, the factors of development and education, the fundamental principles of sustainable development and strategic fields are the main factors of the field shown in Table 3.

Table 3. Categories and concepts related to contextual conditions

Categories	Concepts
Development and training factors	• Growth and development of culture and attitude based on building information modeling technology in the light of sustainable development in the construction industry • Technological and technical factors of construction industry and organizations active in this industry
The fundamental principles of sustainable development	• Coordination and alignment of building information modeling technology with sustainable development in the construction industry • Vision, mission, policies and goals of the construction industry • Ethical system and fundamental principles governing the construction industry • Sustainable development in organizations active in the construction industry
Strategic fields	• Policies and characteristics of sustainable development and construction industry • Cultural and social factors of construction industry and organizations active in this industry • Economic factors of construction industry and organizations active in this industry • Political and legal factors of construction industry and organizations active in this industry

Intervening Conditions

Intervening conditions include more general conditions such as time, space and culture, which act as facilitators or limiters of strategies. These conditions act in the direction of mutual facilitation or limitation in a specific context and each of these conditions forms a spectrum whose influence varies from very far to very close. In this research, three categories of structural factors and managerial factors and information technology are considered as intervening categories, which are shown in Table 4.

Table 4. Categories and concepts related to intervening conditions

Categories	Concepts
Structural factors	• Construction industry infrastructures and existing potentials • Individual motivation and organizational motivation of researchers for sustainable development in the construction industry • Accountability and support of managers in organizations active in the construction industry • Management stability in organizations active in the construction industry
Management factors and information technology	• Education and training of people with the capabilities, capabilities and skills of building information modeling in organizations active in the construction industry. • Creating a multi-capacity training environment for new technology in organizations active in the construction industry • Continuous training and development system in the construction industry • Promoting the culture of building information modeling in the construction industry

Axial Category

The considered phenomenon must be central, that is, all other main categories can be related to it and appear repeatedly in the data. In the sense that in all or almost all cases, there are signs that point to that concept. Axial Category is the result of causal conditions, building information modeling and promotion of sustainable development indicators. In fact, the results of the analysis of the interviews lead the researcher to the conclusion that the heart of the sustainable development process is based on the building information modeling that is presented to him. Table 5 shows Axial Category.

Table 5. Categories and concepts related to Axial conditions

Categories	Concepts
Building information modeling and promoting sustainable development indicators	• Visual simulation of projects using building information modeling • Increasing quality and efficiency in all stages of construction • Clarify the planning of construction projects • Facilitating cooperation between project stakeholders

Strategies

Strategies are actually plans and actions that are the output of the central category of the model and end in consequences. Strategies are a set of measures that are taken to manage, administer or respond to the phenomenon under investigation. The researcher according to the set of concepts extracted from the interviews and the final codes; The strategies in the two categories of optimal building design and integration of contractual models and sustainable development and saving natural resources are as follows, and Table 6 shows the categories and concepts related to the strategies.

Table 6. Categories and concepts related to the conditions of strategies

Categories	Concepts
Optimum building design and integration of contract models	• The infrastructure of building information modeling • Using the best technologies and technologies in the field of construction • Requirements for using smart technology for building information modeling • Environmentally friendly building design • Strengthening the sustainability approach using building information modeling
Sustainable development and conservation of natural resources	• Increasingly promoting and strengthening the culture of environmental protection • Infrastructures with increasing attention to sustainable development • The mission of promoting sustainable development in the construction industry • Policies to promote sustainable development in the construction industry • Procedures for promoting sustainable development in the construction industry • Policies and laws supporting the country's sustainable development in the field of construction

Consequences

Consequences are the outputs with the results of actions and reactions. The last part of the consequences model in the construction industry includes infrastructural consequences, organizational consequences and macro consequences. According to the open coding, the concepts related to the consequences of the example have been extracted, then according to the back-and-forth movement between the themes and concepts, the main categories have been extracted and named, based on which the consequences are divided into three sections related to infrastructural, organizational and macro level. It is framed. Table 7 deals with categories and concepts related to consequences.

Table 7. Categories and concepts related to the conditions of consequences

Categories	Concepts
Infrastructural implications	• Improving sustainable development indicators • Reducing environmental impacts • Reducing the economic effects of construction • Reducing the social effects of construction
Organizational implications	• Improving energy efficiency • Optimal design of buildings • Improving the life cycle of the building • Achieving buildings that comply with sustainability factors by using building information modeling technology
Macro consequences	• Meeting the needs of the day without creating danger for the future generation • Saving natural resources • Sustainable economic growth

Selective Coding

Selective coding uses the results of the previous steps of coding, selects the main categories connects them to other categories in a systematic way, and validates the connections and the categories that need to be posted and further developed. promotes the pattern model of this research was designed based on Strauss and Corbin's pattern. In this model, causal conditions, and environmental, technological, and environmental factors are shown based on building information modeling in the construction industry. Despite these factors and conditions, the components affecting the sustainable development of the construction industry were identified based on building information modeling, which are the background conditions, development and training factors, the fundamental principles of sustainable development, and strategic areas for improving sustainable development, which are the conditions for success. Better to implement this process, they should be considered more. If the intervening conditions have a positive or negative effect on the process of sustainable development of the construction industry, they can disrupt, facilitate, and accelerate the implementation of sustainable development. In this process, the most important factor in improving sustainable development is building information modeling and promoting sustainable development indicators as a central category. Although it cannot be said that this category is the most important, it must be said that without this category, the process of sustainable development based on building information modeling is not possible. The strategic factor of the model is the optimal design of the building and the integration of contractual models and sustainable development and saving of natural resources, and the consequences, infrastructural consequences, organizational consequences, and macro-society consequences were considered; Consequences whose manifestation means the emergence of the phenomenon of sustainable development based on building information modeling. The research model is shown in Figure 1.

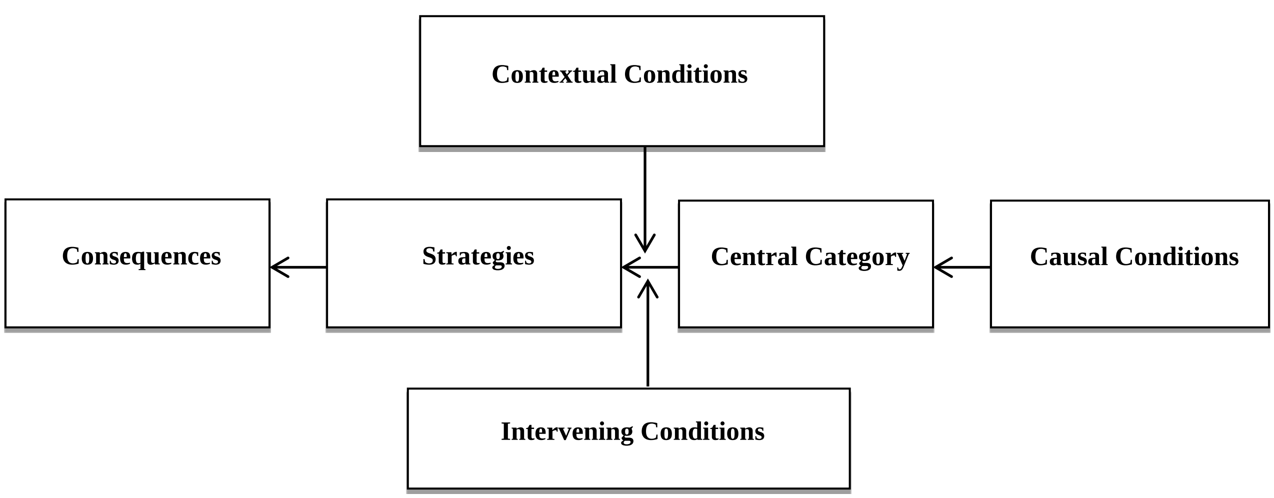

Figure 1. Research model

Validation of the Model

The stage after the presentation of the model, which is the output of the qualitative part of the research and is the result of the interview and theorizing theory of the foundation data (theorizing), is the turn of analyzing the quantitative part of the research or testing the model (testing the theory) using the structural equation model. It should be noted that in this section, first, a questionnaire was compiled based on the indicators, components, concepts, and categories of the proposed model, and this questionnaire contains 55 questions. The presented questionnaire has a scale There are five Likert scales, which are very low (with a score of 1), low (with a score of 2), moderate (with a score of 3), high (with a score of 4) and finally very high (with a score of 5). Validity opinion (in this way, the questionnaire was given to the experts and specialists as well as respected professors and advisors, and they were asked for their opinions on each question and regarding the evaluation of the relevant goal, and with minor modifications, the validity of the questionnaire was confirmed) and Reliability (in this way, the questionnaire was distributed and collected preliminarily among a number of the investigated community and entered into SPSS software and Cronbach's alpha was calculated, considering that the alpha of the questionnaire is higher than 70%, so it can be claimed that the questionnaire has the necessary reliability) was examined and confirmed and distributed among the research community. Out of 400 distributed questionnaires, 390 questionnaires were returned, of which 384 completed questionnaires were used in the analysis. The average return rate of the questionnaire was 97%. Considering the research culture in the country, the rate is satisfactory. After collecting the data, to check the research model, the structural equation modeling method based on covariance was used and the confirmatory factor analysis technique was used. In this section, the measurement models of the structural equation model: under the measurement of the structures by the relevant indicators; To test the general structure of the structural model of the research, due to the use of second-order variables and the existence of moderating relationships, the method of structural equation modeling based on partial least squares has been used, therefore, SmartPLS.3.0 software has been used. In Table (8) the research concepts and factors along with their equivalents used in the analyses are shown, which will be useful when viewing the results.

Table 8. Abbreviated names of variables in Smart PLS software

Row	Variable	Abbreviated Name
1	Causal conditions	ELI
2	central category	MEHVARI
3	Strategies	RAHBORD
4	Contextual	ZAMINE
5	Intervening conditions	MODAKHELEGAR
6	Consequences	PAYAMAD

The statistical population of the research includes all civil engineers and project managers in the construction projects of the 3rd district of Tehran, who have enough information to answer the questionnaire, and their number is undetermined. To determine the minimum required sample size, Morgan's table was used for the unlimited population. Therefore, the minimum required sample size was 384 people. Due to the fact that the studied population is homogeneous, simple random sampling method was used for sampling, and the sample of each class was chosen randomly (Table 9).

Table 9. Demographic characteristics of the respondents

Characteristics of the Respondents		F	%`
Gender	M	308	80.2
	F	76	19.8
Age	<30	52	13.5
	31-35	78	20.3
	36-40	154	40.1
	>41	100	26
marital status	Married	104	27.1
	Single	280	72.9

Education	Masters	127	33.1
	MSc	180	46.9
	P.H. D	77	20.1

Table 10 shows the tests of the research model with the help of Smart PLS software, which all show the confirmation of the structural model:

Table 10. Test indicators

Variable	Sub-index	factor load	Cronbach's alpha	CR	AVE
(ELI)	q1	0.788	0.839	0.893	0.675
	q2	0.822			
	q3	0.844			
	q4	0.832			
	q5	0.597	0.830	0.891	0.677
	q6	0.834			
	q7	0.910			
	q8	0.910			
	q9	0.995	0.988	0.992	0.978
	q10	0.990			
	q11	0.981			
(MEHVARI)	q12	0.773	0.831	0.888	0.666
	q13	0.852			
	q14	0.868			
	q15	0.766			
(RAHBORD)	q16	0.740	0.854	0.897	0.639
	q17	0.901			
	q18	0.678			
	q19	0.911			
	q20	0.739			
	q21	0.670	0.817	0.868	0.524
	q22	0.746			
	q23	0.627			
	q24	0.777			
	q25	0.772			
	q26	0.732			
(ZAMINE)	q27	0.912	0.806	0.912	0.838
	q28	0.918			
	q29	0.863	0.882	0.919	0.739
	q30	0.859			
	q31	0.875			
	q32	0.841			
	q33	0.780	0.785	0.861	0.609
	q34	0.842			
	q35	0.764			
	q36	0.731			
(MODAKHELEGAR)	q37	0.744	0.710	0.820	0.533
	q38	0.786			
	q39	0.700			
	q40	0.687			
	q41	0.814	0.838	0.892	0.674
	q42	0.875			
	q43	0.815			
	q44	0.776			
(PAYAMAD)	q45	0.839	0.862	0.907	0.708
	q46	0.869			
	q47	0.829			
	q48	0.829			
	q49	0.783	0.811	0.876	0.638
	q50	0.799			
	q51	0.792			
	q52	0.819			

	q53	0.838	0.774	0.869	0.688
	q54	0.801			
	q55	0.849			

DISSECTION AND RESULT

The main purpose of the research was to design and explain the combined model of building information modeling and foundation data theory to promote sustainable development indicators of the construction industry based on a systemic approach (Strauss and Corbin, 1998) and with a mixed (qualitative-quantitative) approach. In two stages, the design of the combined model of building information modeling and foundation data theory has been carried out to improve the indicators of sustainable development of the construction industry, and the test of the combined model of building information modeling and foundation data theory has been done to improve the indicators of sustainable development of the construction industry.

The steps of the research progressed step by step based on the foundation's data theorizing method, and finally, based on the research literature and conducted interviews, 55 concepts and 14 categories were counted. Along with 13 other items, the data theory components form the foundation obtained from the research. The central category identified in this research is building information modeling and promotion of sustainable development indicators, with which the rest of the categories make sense. The categories were placed in the five categories of background or context (3 categories), intervening conditions (2 categories), causal conditions (3 categories), strategies (2 categories), consequences (3 categories) to be presented in the visual model, as described is as follows:

- Building information modeling and promoting sustainable development indicators is considered as a central category, which includes 4 characteristics: 1) visual simulation of projects using building information modeling; 2) increasing the quality and efficiency in all stages of construction; 3) clarifying the planning of construction projects; 4) Facilitating cooperation between project stakeholders.
- Also, among other categories, three categories "environmental factors", "technological factors" and "environmental factors" are considered as causal conditions.
- In addition, among other categories, two categories of "structural factors", "management factors and information technology" are considered as intervening conditions.
- Also, the categories of 1) development and training factors; 2) the fundamental principles of sustainable development; 3) Strategic fields are also considered as background conditions, because these categories indicate specific conditions in which action and reaction strategies take place.
- The categories of 1) optimal building design and integration of contractual models and 2) sustainable development and conservation of natural resources; are also considered as strategies, because these categories are purposeful actions and reactions that lead to the establishment of a suitable pattern.
- And finally, the categories of 1) infrastructural consequences, 2) organizational consequences, and 3) macro consequences are considered as the results and consequences of the design and explanation of the combined model of building information modeling and foundation data theory to promote sustainable development indicators of the construction industry. Because these categories are the results of actions and reactions.

1. Environmental factors are a sufficient indicator of causal conditions; Due to the fact that the factor load related to the questions of the environmental factors variable is higher than 0.5 and also the significance coefficient related to the questions of this variable is higher than the value 1.96; Also, the values of Cronbach's alpha (0.839) and composite reliability (0.893) are higher than 0.7 and the average variance extracted (0.675) is higher than 0.5; Therefore, environmental factors are confirmed as a component of causal conditions.

2. Technological factors are a sufficient indicator of causal conditions; Considering that the factor load related to the questions of the technological factors variable is higher than 0.5 and also the significance coefficient related to the questions of this variable is higher than the value 1.96; Also, the values of Cronbach's alpha (0.830) and composite reliability (0.891) are higher than 0.7 and the average variance extracted (0.677) is higher than 0.5; Therefore, technological factors are confirmed as a component of causal conditions.

3. Building information modeling and promotion of sustainable development indicators is a sufficient indicator of the central category. Considering that the factor load related to the variable

questions of building information modeling and promoting sustainable development indicators is higher than 0.5 and also the significance coefficient related to the questions of this variable is higher than 1.96; Also, the values of Cronbach's alpha (0.831) and composite reliability (0.888) are higher than 0.7 and the average variance extracted (0.666) is higher than 0.5; Therefore, building information modeling and promoting sustainable development indicators are confirmed as a core category component.

Considering that the model proposed in this research included different levels of analysis, therefore, we tried to make specific practical suggestions based on objective problems and problems and analyze the findings of this research in the form of qualitative exploratory interviews with experts and questionnaires. distributed among the investigated community, which are described below. By analyzing the interviews and based on the conducted interviews and the statements of the managers, it can be concluded that the construction industry is unfortunately not in a favorable situation in terms of sustainable development indicators so some of the experts in the community have a positive attitude towards the category of indicators. has not had sustainable development and some others have even gone further and disrupted and resisted. The traditional experts may be against this program and resist it during the implementation phase. Various reasons have been proposed. Sustainable development is based on the fact of creating a balance between development and the environment. Sustainable development is a process that integrates the economic, social, and environmental goals of the society wherever possible through the establishment of policies, taking necessary measures, and support operations, and wherever integration is not possible, establishing an exchange relationship between them. The coordination of these exchanges pays, so the integration of building information modeling and sustainable development is highly recommended. Considering that construction contracts play a major role in the construction of sustainable buildings, both in the implementation phase and in the exploitation phase. In numerous reports of employers, the lack of a strategic direction in the interaction, role, and responsibility of their employees in the fields related to sustainability has been mentioned, so it is suggested that by using building information modeling technology in this field, they will make the most accurate analysis of the costs and the most appropriate Get a schedule. It is suggested that construction industry experts should be pioneers in promoting sustainable development indicators and should be creative and innovative in this direction and constantly seek to use new working methods to make building information modeling more efficient. At the same time, they should try to provide a space and platform so that other people in the construction field can help in this creative way. Also, among other suggestions that can be recommended to managers, the following can be mentioned: Positive and optimistic attitude and view of experts towards building information modeling and its decisive role in the future success of construction Action-oriented will of company managers to invest in technology and technology, and building information modeling. Providing the right platform and conditions for the implementation of building information modeling to promote the sustainable development of the construction industry. Considering and allocating the necessary financial budget for the implementation and deployment of the building information modeling program in the construction industry. The development of new technologies and international standards and the requirement to use them in the construction industry to promote the sustainable development of the construction industry. Development of extensive national infrastructure necessary to facilitate the establishment of building information modeling in the construction industry. Providing building information modeling training platforms and facilitating learning for professionals in the construction industry.

REFERENCE

Basel Sultan & Wael Alaghbari (2023) Construction industry sustainable development indicator for low-income developing countries: Yemen as a case study, International Journal of Construction Management, 23:6, 1053-1060, DOI: 10.1080/15623599.2021.1951429

Cavalliere, C., Habert, G., Dell'Osso, G. R., & Hollberg, A. (2019). Continuous BIM-based assessment of embodied environmental impacts throughout the design process. Journal of Cleaner Production, 211, 941-952.

Chen, S., Feng, K., & Wang, Y. (2018). The Application of Building Information Modelling in Sustainable Construction: A Literature Review. Sustainable Construction and Prefabrication (pp. 21-37). Reston, VA: American Society of Civil Engineers.

Chong, H. Y., & Wang, X. (2016). The outlook of building information modelling for sustainable development. Clean Technologies and Environmental Policy, 18(6), 1877-1887.

Chong, H. Y., & Wang, X. (2016). The outlook of building information modelling for sustainable development. Clean Technologies and Environmental Policy, 18(6), 1877-1887.

Creswell John, W. (2007). Qualitative inquiry and research design: Choosing among five approaches. Lincoln: Sage Publications.

Fadeyi, M. O. (2017). The role of building information modelling (BIM) in delivering the sustainable building value. International Journal of Sustainable Built Environment, 6(2), 711-722.

Gamil, Y., Rahman, I.A., Nagapan, S., Nasaruddin, N.A.N., (2020). Exploring the failure factors of Yemen construction industry using PLS SEM approach, Asian Journal of Civil Engineering, https://doi.org/10.1007/s42107-020-00253-z

Hall, A. T., Durdyev, S., Koc, K., Ekmekcioglu, O., & Tupenaite, L. (2022). Multi-criteria analysis of barriers to building information modelling (BIM) adoption for SMEs in New Zealand construction industry. Engineering, Construction and Architectural Management, (ahead-of-print).

Haruna, A., Shafiq, N., & Montasir, O. A. (2020). Building information modelling application for developing sustainable building (Multi criteria decision making approach). Ain Shams Engineering Journal.

Heydari Khalaf Badam, M. M., & Barmayehvar, B. (2022). Exploration of effective factors in enhancing sustainable construction in the building industry with a green project management approach through PRISM. Art of Green Management, 1(2), 75-86.

Juan, Y-K., Lai, W-Y., Shih, S-G. (2017). BUILDING INFORMATION MODELING ACCEPTANCE AND READINESS ASSESSMENT IN TAIWANESE ARCHITECTURAL FIRMS, JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT, Volume 23(3): 356–367.

McArthur, J. J. (2015). A building information management (BIM) framework and supporting case study for existing building operations, maintenance and sustainability. Procedia engineering, 118, 1104-1111.

Mohammadi S, Taghipour M, Mahboobi M. Investigating the role and impact of using ICT tools on evaluating the performance of service organizations. Iranian Journal of Information Processing and Management 2021; 37(1): 1–26. doi: 10.52547/JIPM.37.1.1

Moosavi SA, Taghipour M. Turbine vibration condition monitoring in region 3. ojs.acad-pub.com2023; 1(1): 1-12. doi: 10.59400/mea.v1i1.219

Ningappa, G. N. (2011). Use of lean and building information modelling (bim) in the construction process; does bim make it leaner? (Doctoral dissertation, Georgia Institute of Technology).

Olawumi, T. O., & Chan, D. W. (2019). Critical success factors for implementing building information modelling and sustainability practices in construction projects: A Delphi survey. Sustainable Development, 27(4), 587-602.

Okoye, P.U., Mbakwe, C.C., & Igbo, E.N. (2018). Modeling the construction sector and oil prices toward the growth of the Nigerian economy: An econometric approach. Economies, 6(1):16. https://doi.org/10.3390/economies6010016

Raut, R., Narkhede, B. E., Gardas, B. B., & Luong, H. T. (2018). An ISM approach for the barrier analysis in implementing sustainable practices. Benchmarking: An International Journal.

Reizgevičius, M., Ustinovičius, L., Cibulskienė, D., Kutut, V., & Nazarko, L. (2018). Promoting sustainability through investment in Building Information Modelling (BIM) technologies: A design company perspective. Sustainability, 10(3), 600.

Saieg, P., Sotelino, E. D., Nascimento, D., & Caiado, R. G. G. (2018). Interactions of building information modelling, lean and sustainability on the architectural, engineering and construction industry: a systematic review. Journal of cleaner production, 174, 788-806.

Sanchez, B., Ballinas-Gonzalez, R., Rodriguez-Paz, M. X., & Nolazco-Flores, J. A. (2020, June). Usage of building information modelling for sustainable development education. In 2020 ASEE Virtual Annual Conference Content Access

Shaker, R. (2017) The spatial distribution of development in Europe and its underlying sustainability correlations. Applied Geography, (63), 304-314.

Taghipour M, Mahboobi M, Gharagozlou H. The impact of ICT on knowledge sharing obstacles in knowledge management process (including case-study). Iranian Journal of Information Processing and Management 2016; 31(4): 1049–1074. doi: 10.35050/JIPM010.2016.003

Taghipour M. A review of the sustainability indicators' application in vehicle routing problem. Building Engineering- Academic Publishing Pte. Ltd 2023; 1(1): 1-13. doi: 10.59400/be.v1i1.221

Taghipour .M; Saffari .K; Sadri .N. Assessment of the Relationship Between Knowledge Managment Implementation and Managers Skills (Case Study: Reezmoj System Company in Iran) .

Science Journal of Business and Management, 2016, Vol 4, Issue 4, 114-120. doi: 10.11648/j.sjbm.20160404.12

Taghipour .M; Nokhbefallah .M; Nosrati .F; Yaghoubi .J; Nazemi .S. ” Evaluation of the effective variables of the value engineering in services” . Journal of Applied Environmental and Biological Sience, 2015, Vol 5(12): 319-322.

Taghipour .M; Shamami .N; Lotfi .A; Parvaei Maryan .S ”Evaluating Project Planning and Control System in Multi-project Organizations under Fuzzy Data Approach Considering Resource Constraints(Case Study:Wind Tunnel Construction Project)” .Management, International Technology and Science Publications (ITS), 2020, Vol 3, Issue 1, 29-46. 10.31058/j.mana.2020.31003

Taghipour M, Moghadam A, Shekardasht MNB. Implementation of software-efficient DES Algorithm. Science Publishing Group 2015; 3(1): 7–22. doi: 10.11648/j.net.s.2015030301.12

Taghipour M, Seraj F, Amir Hassani M, Farahani Kheirabad S. Risk analysis in the management of urban construction projects from the perspective of the employer and the contractor. International Journal of Organization Leadership 2015; 4(4): 356–373. doi: 10.33844/ijol.2015.60284

Teng, Y., Xu, J., Pan, W., & Zhang, Y. (2022). A systematic review of the integration of building information modelling into life cycle assessment. Building and Environment, 109260.

Yuan, Y., & Yuan, J. (2011). The theory and framework of integration design of building consumption efficiency based on BIM. Procedia Engineering, 15, 5323-5327.

Zhang, L., Chu, Z., He, Q., & Zhai, P. (2019). Investigating the constraints to buidling information modeling (BIM) applications for sustainable building projects: A case of China. Sustainability, 11(7), 1896.