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Developing F-AHP green and lean construction project management technique in hospitals building design

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ABSTRACT

Lean construction is regarded as a system of managing construction-related processes to maximize the output of labor; time and expense by continuously enhancing the project performance. Healthcare facilities and hospital buildings considered as a strategic building in developing countries. For that in this paper, the characteristics of a lean construction project's analyzed project feasibility efficiently based on green concept, allowing them to establish an effective model for lean construction. Furthermore, early-stage decisions have a huge impact on green buildings. The process of implementing the paper methodology stars with specifying and collecting the effective factors based on lean and green concepts. The Environment, Security, Patient Movement, Material Specification requirement, Occupancy, HVAC and Ventilation, Medical sewage pipeline, electrical system, Water supply and drainage system have been considered the main lean factors while the Livable design conditions factors and indoor design condition factors considered the green factors. The Delphi method and F-AHP technique have been used to investigate the effect of these factors. Also, the construction of structural Medical system measured. The results observe a which of these factors important in building hospital design and how its effect.

Keywords: F-AHP green, construction project, building design, management technique, hospitals

Introduction

Lean Thinking is a concept that is based on the Toyota Production System (T. P. S.). It was ultimately developed in a manufacturing environment, more specifically in the automotive industry. Toyota's chief engineer Taichii Ohno and the C. E. O. Eiji Toyoda are the leading proponents of lean thinking. They were committed to getting rid of both hidden and visible garbage. Following Toyota's significant competitive edge over American and local competitors, particularly during the 1973 oil crisis, the method attracted a lot of attention. A member of the International Motor Vehicle Program (I. M. V. P.) team invented the phrase "lean production," which was first used in the book "The Machine That Changed the World." James P. Womack and Daniel T. Jones of the Massachusetts Institute of Technology led the team (M. I. T.). The Toyota Production System was referred to as TPS. The I. M. V. P. team undertook a five-year international research project that resulted in the book that popularized the word "lean." The research contrasted Henry Ford's mass production system, which was exponentially expanded at General Motors and used by practically every major company in the world at the time (excluding Toyota), to Ohno and Toyoda's manufacturing method. Toyota's manufacturing approach was dubbed "lean production" by the I. M. V. P. team, which refers to minimizing inventory, being flexible, and eliminating waste. As a result, lean production is essentially the Toyota Production System. The lean production system, like any other manufacturing system, is designed to create high-quality products in the shortest feasible time with the least amount of resource investment at the lowest possible cost. Lean manufacturing introduces some novel notions; it is essentially the consolidation of tried-and-true procedures into effective processes.

Green construction refers to the philosophy and processes that make the creation and usage of the built environment as friendly to the natural environment as possible. From the design stage to assembly to the functionality of the structure upon completion, green construction focuses on reducing negative impacts on the planet and even adding some positive benefits. Humans require homes to live in, schools to study in, companies to work in, and highways to travel on, therefore construction is a fundamental aspect of contemporary life. Any building will have an unavoidable environmental impact. With an increasing worldwide emphasis on sustainability, the construction industry must take efforts to both reduce their own footprint when constructing a new structure and design that structure to run in a sustainable manner for many years to come. Green construction is a fast increasing area of the business that answers that need. The following are some of the green construction movement's new methods and inventions. A green construction uses less energy, water, makes less waste, maintains the tenants' indoor air quality, and uses efficient building materials. Green architecture allows for more effective resource usage while also generating healthier environments. Aside from the energy and CO2 savings, the building maintains a suitable internal climate for its tenants throughout the year, independent of seasonal weather changes. Because of the thermal comfort of green building, many people believe that it solely comprises delivering air-conditioned services and that it requires a considerable investment. This was somewhat accurate in the early days of green building, when it was still a new technology. Green construction users, on the other hand, have proved that these assumptions are erroneous.

Related works

it is necessary to develop effective and reliable models and procedures that will aid project teams in addressing the problems associated with wastes in projects. This can only be accomplished by implementing lean production techniques inside the construction sector, hence the term "Lean Construction" (LC). The benefits that the client is actually paying for the project to provide and install must be stressed. Engineering (or design), which integrates many processes carried out concurrently by diverse teams with the objective of improving engineering cycles of production for efficiency, quality, and functionality, aims at maximizing client satisfaction **[1]**. The potential and chances of implementing lean construction techniques and equipment to improve the structure of the construction industry are covered in this essay. Four key applications of lean construction's philosophy and tools could be pinpointed: employee engagement, cost-cutting, process improvement, and loss prevention. In addition to methods and tools for involving workers in lean production, lowering expenses and trying to prevent losses, and optimizing, and automating the production process at the level of strategic and operational management, the paper discusses the outcomes of applying the concept of lean construction in other regions. At all levels of management, the distinctiveness of the tools and work procedures used in the construction sector is defined. The adoption of the lean construction idea is justified since it enables businesses to become more competitive and productive **[2]**. The acceptance, understanding, and advantages of Lean Construction tools in the construction sector are examined in this research. **[3]**. By embracing lean construction, many nations have remarkably removed their building delays and environmental problems. The decrease in construction costs and the promotion of sustainable development are the low-ranking advantages **[4]**.

Lean Construction Management Tools

Many authors have reviewed different lean tools for attaining sustainable development. However, there are only a relatively small number of studies that have examined various sustainability challenges using lean construction efforts and determined the advantages that may be obtained by using the lean tools. The goal of this researrch is to examine, using a review of the scientific literature, how the idea of sustainability and different lean construction technologies relate to one another. The following LCs are determined to be the most suitable for the construction industry according to a review of scientific research studies carried out in various nations: Visual management (VM), Last Planner System (LPS), Building Information Modeling (BIM), 5S, Prefabrication, Analysis of roots causes, Just In Time, Value Stream Mapping (VSM), and Poka-Yoke. According to the study results, it has been proven that these LC techniques (prefabrication, value stream mapping, poka-yoke, visual management, and 5S) directly influence the advancement of the primary elements of sustainable development. In fact, our research has shown that lean construction may help advance social and environmental challenges in addition to adding economic value to the construction process. This ideology provides a solid conceptual foundation for achieving sustainability goals **[5][6]**. Lean thinking makes it easier to conceptualize these ideas. In industrial businesses, several Lean procedures and approaches have been created and put into operation to increase efficiency. In other fields, like construction, some of them have demonstrated greater effectiveness. The Lean tools that have developed and are now employed in the construction industry are listed below **[7][8]**. the biggest obstacles to LC include technological and knowledge obstacles, leadership and managerial obstacles, complexity and cultural barriers, involvement and connection barriers, financial constraints, and communication limitations. The endurance of time and other resource waste, as well as the loss of value that characterized the implementation of construction projects, have been referred to the spread of these hurdles in the construction sector. These are also some of the main reasons for quality decline, rework, material waste, safety concerns, efficiency challenges, complaints, and conflicts **[9]**. The biggest obstacles to implementing lean were top management assistance lack, inadequate training for employees, absence of appropriate lean knowledge and understanding, insufficient management of the essential knowledge to create a learning cycle and perform proper actions, and an absence of participation and clarity between stakeholders **[10]**. Another study seeks to categories and determine the barriers to poor Lean thinking execution. First, the study began with a review of the literature and discussion with six specialists with more than ten years of experience implementing lean construction in various project types, who identified 32 barriers to implementation and classified them into four categories: cultural barriers, technological barriers, lean philosophy barriers, and other barriers. Numerous engineers from diverse projects are polled, and the biggest challenges to implementing lean construction are ranked **[11]**. Another article's goal is to assess the elements that have an impact on the use of lean construction at particular construction projects in Malaysia's Klang Valley. The lean construction's implementation obstacles were assessed using an evaluation index method that included a survey and interviews **[12]**. While Sri Lanka's construction sector is still in its infancy (a stage of awareness raising), lean construction (LC) efforts clearly show to be very fruitful for the UK market **[13]**.

Lean Construction Success Factors

Lean management strives to reduce waste and increase customer satisfaction. However, the complicated, dynamic, and project-based nature of building projects raises questions about whether lean implementations will be successful (i.e., schedule improvement, finance, safety, and quality). This study's main goal is to put out a thorough success model for Lean execution in the construction sector. Based on a thorough review of the literature, a group of success criteria was defined for this situation. The criteria are split into seven categories: finance, management, technically, labor, environment, government, and communications. When the relevance weights of these attributes have been determined by the five-person expert team, an analytical network process (ANP) model is then created to identify the connections between the success-related attributes. Eight professional civil engineers completed a two-part questionnaire to provide the information needed for the ANP model. The results stated that the key success criteria for Lean implementation were determined to be market share, access to Lean tools and techniques, and lean training **[14]**. Young businesses might employ new strategies to maintain a sufficient level of competition, it was also discovered. As a result, they may serve as the industry's early adopters of lean construction. Stressing Lean Construction's capacity to save money might be a significant motivator to encourage its adoption given the importance of financial factors for such businesses **[15].** The experts also agreed that promoting the interoperability of technological systems is essential for a successful deployment of LC, as well as collaboration and communication among construction industry professionals. The experts also stated that it is essential to comprehend each client's needs in order to give value to the application of the LC. The experts also highlighted national level cooperation, the promotion of LC, and long-term supply chain partnerships as being extremely important elements. A cutting-edge concept for building lasting connections throughout the whole supply chain is the lean strategy. The majority of the experts felt that applying LC at the beginning phases of project development is a CSF since it is crucial to incorporate LC into the project delivery process **[16]**. Although green construction is advocated as a way to create a more sustainable environment, many developing nations' construction projects have a dismal track record when it comes to sustainability. Beyond lessening the damaging effects of construction processes on the environment, green construction benefits can increase productivity **[17]**.

Table 1: hospital zoning factors

Z1	The nursing zone.
Z2	The administrative zone.
Z3	The surgical zone.
Z4	clinical department zone

Z5	The emergency zone.
Z6	The prevention and healthcare zone.
Z7	services zone

Table 2: hospital design factors

F1	Environment.
F2	Security.
F3	Patient Movement.
F4	Material Specification requirement.
F5	parking
F6	Occupancy.
F7	HVAC and Ventilation.
F8	Medical sewage pipeline.
F9	electrical system
F10	Water supply and drainage system.

Table 3: hospital building Structure system factors

	Structure system.
SF1	Foundation.
SF2	Floor slab.
SF3	Structural element.

Table 4: Medical system factors

	Medical system.
MF1	Operating room.
MF2	Clinical laboratory.
MF3	General ward.
MF4	Intensive Care Unit.
MF5	X-ray room.
MF6	MRI Scanning Room.

The following suggestions were made in light of the findings: Due to the negative effects that construction operations have on the environment, (1) a construction company's implementation of environmentally friendly processes is crucial to the company's success; (2) public knowledge about green construction is crucial because it results in a good quality and, as a result, better green construction delivery; and (3) the authority should promote green construction **[18] [19]**. Through all forms of mass communication, experts are continuously working to combat these drawbacks and strive to adhere to the standards set at the worldwide level. On its path to becoming more ecological and "green," the construction industry will face difficulties from the growth of the circular economy and the utilization of resources efficiently. The implementation will encourage investment and have positive effects on the built environment, the environment, and citizens over the short and long terms **[20]**. It is evident that green construction could aid in reducing climate change, but implementing it in Malaysia's construction industry would take some time. Also, lack of awareness on the existing incentives and the limitation of information and databases are considered to be among the barriers to implement green construction **[21]**.

The fuzzy-AHP method

A decision support technique called the Analytic Hierarchy Process (AHP) was created to solve issues by segmenting the solutions into smaller groups and then placing those groups into a hierarchical framework. This approach compares the criteria together with a predetermined measuring scale to establish the priority criteria. The primary input for the AHP approach is the opinion of experts, hence retrieval decisions are subject to subjectivity. This approach also considers the constraints of data inconsistent validity. The F-AHP approach was created in this part. The steps taken in the suggested approach are explained in the following manner.

1. Fuzzy AHP is used to address AHP's limitations in dealing with subjectivity and fuzziness in the decision maker's judgments. As a result, it is a multi-criteria method built on AHP but uses a range of values to account for the decision-uncertainty. maker's The algorithm created by Van Laarhoven and Pedrycz, which is a direct extension of the original AHP technique, the Buckley approach for introducing fuzzy comparison ratios into the methodology, Chang's Extent Analysis Method, and Cheng's entropy-based Fuzzy AHP are just a few of the methodologies employed.

2. This is a multicriteria strategy that is based on AHP but employs a range of values to account for the decision-uncertainty, maker's ambiguity, or hesitation. The algorithm created by Van Laarhoven and Pedrycz, which is a direct extension of the original AHP approach, and the Buckley method for introducing fuzzy comparison ratios into the methodology are two other methodologies that have been developed for using it. Other approaches include Cheng's entropy-based fuzzy AHP and Chang's extent analysis method.
3. Combining fuzzy sets theory with AHP to take into account uncertainty in the decision-making

process

4. RESULTS AND DISCUSSION

The goal of the current study was to choose the best engineering design for building projects. The difficulties in building projects are caused by the cooperation of the components in defining the cost condition. The cost variables for this project have been chosen according to table 4.1, which ranks the efficacy of each cost component. These elements were present in the instance of an Iraqi hospital under development. The scenarios progressed in two key phases. The initial step is to identify practical value contrasts that might offer useful data for classifying the kind of roof. The Fuzzy AHP was used to determine the optimal option in order to reach this level. The established AHP algorithm was then put to the test in order to see how well the cost considerations for roofs worked. How to handle these enormous amounts of data is the key difficulty in the current study. The data are categorized and structured by the researcher in a way that may effectively represent the current approach.

The Fuzzy AHP approach evaluates choices using this idea. Obviously, certain elements are more important than others. Giving the appropriate amount of weight might thereby resolve the issue. Despite the fact that some managers believe some criteria to be more crucial than others, they may operate in the opposite manner in actuality. Managers seem to value quality above all else, but when it comes to selecting a cost factor, they prioritize cost and/or delivery performance. These results imply that, despite managers' perceptions that several factors, including quality, matter in deciding which cost components to use, the low cost element is really picked. Based on the cost factors taken into consideration, the priority weight of each criterion in each level was determined. The crucial criteria were discovered using the pair-wise comparison judgements. As stated in Table 5, the purpose of the pair-wise comparisons is to determine the relative relevance of the criteria, which are scored using the nine-point scale given by Saaty (1980).

Table 5: Fuzzy AHP

Livable design conditions factors	FAHP results	indoor design condition factors	FAHP results
Z1 F1	0.147	Z1 F6	0.255
Z1 F2	0.267	Z1 F7	0.143
Z1 F3	0.201	Z1 F8	0.213
Z1 F4	0.229	Z1 F9	0.210
Z1 F5	0.155	Z1 F10	0.179
Z2 F1	0.329	Z2 F6	0.147
Z2 F2	0.177	Z2 F7	0.267
Z2 F3	0.184	Z2 F8	0.201
Z2 F4	0.136	Z2 F9	0.229
Z2 F5	0.174	Z2 F10	0.155
Z3 F1	0.080	Z3 F6	0.272
Z3 F2	0.147	Z3 F7	0.178
Z3 F3	0.235	Z3 F8	0.146
Z3 F4	0.366	Z3 F9	0.223
Z3 F5	0.172	Z3 F10	0.181
Z4 F1	0.080	Z4 F6	0.177
Z4 F2	0.147	Z4 F7	0.242
Z4 F3	0.235	Z4 F8	0.208
Z4 F4	0.366	Z4 F9	0.232
Z4 F5	0.172	Z4 F10	0.142
Z5 F1	0.085	Z5 F6	0.249
Z5 F2	0.175	Z5 F7	0.216
Z5 F3	0.248	Z5 F8	0.173
Z5 F4	0.329	Z5 F9	0.244
Z5 F5	0.164	Z5 F10	0.118
Z6 F1	0.076	Z6 F6	0.244
Z6 F2	0.153	Z6 F7	0.097
Z6 F3	0.243	Z6 F8	0.097
Z6 F4	0.383	Z6 F9	0.130
Z6 F5	0.146	Z6 F10	0.432
Z7 F1	0.112	Z7 F6	0.043
Z7 F2	0.107	Z7 F7	0.105
Z7 F3	0.236	Z7 F8	0.196
Z7 F4	0.358	Z7 F9	0.328
Z7 F5	0.187	Z7 F10	0.328

The weightiest of the other elements is undoubtedly the effective aspects in hospital structures. The first three rows demonstrate how the components' weights stack up well against one another. Quality is a somewhat more important factor than delivery, management and organization, and financial success for the second row and column. Assigned that delivery (row) and delivery (column) are equally preferred, the diagonal components are given a value of 1. (column). After obtaining the pair-wise assessments, the next step is to calculate the weighting of the matrix's entries. Divide the items in the column by the column total after computing the total for each column. Finally, split this by the variety of rows and columns. Divide the components of each column by the column total after adding up each column's total. To calculate the average, add the items in each of the resultant rows, then divide that total by the number of elements in the row. shows how the matrix was calculated. It is recommended as the best roof among them based on this outcome and the hazy preferences of the decision-makers. The Alternatives once more outperform the others when this result is compared to the Fuzzy technique for the identical case study. the outcome has almost the same values and can be regarded as the second-best options. The outcomes of this study, however, greatly outperform and are comparable to the second-best results.

Figure 2: results of F-AHP of Structure system

The differences in the results of the two techniques provide a significant indication of the costs involved. In conclusion, the model that was built is helpful in determining which type of building roof should be used. It requires a variety of steps, including generating criteria for the selection of building elements, defining sub-criteria, constructing the hierarchical model, prioritizing the order of criteria, calculating roof cost, and deciding roof priority and selection, in that order.

CONCLUSION AND RECOMMENDATION

The Fuzzy AHP technique is used to estimate the rank among hospital construction variables where all of the design conditions are identical and the designer engineer is tasked with making the most optimal decision possible. Research has been done looking at how important the fuzzy AHP technique

Factor	Rank %
MF1	4%
MF2	8%
MF3	11%
MF4	15%
MF5	31%
MF6	31%

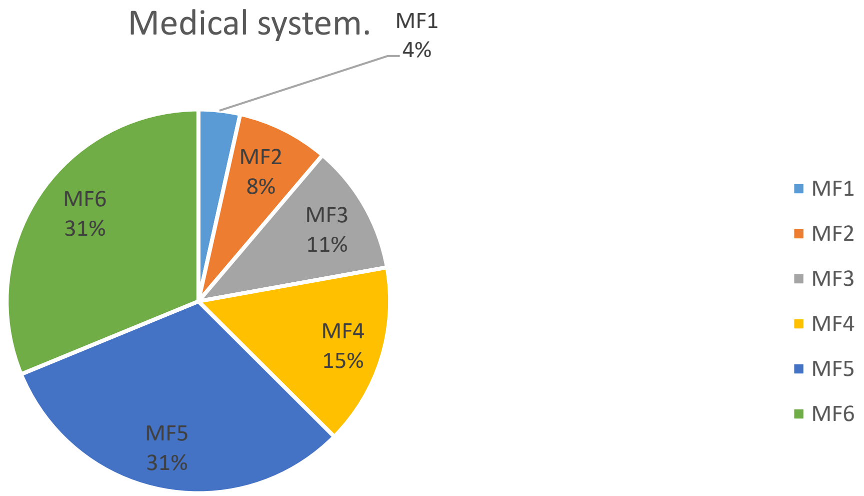
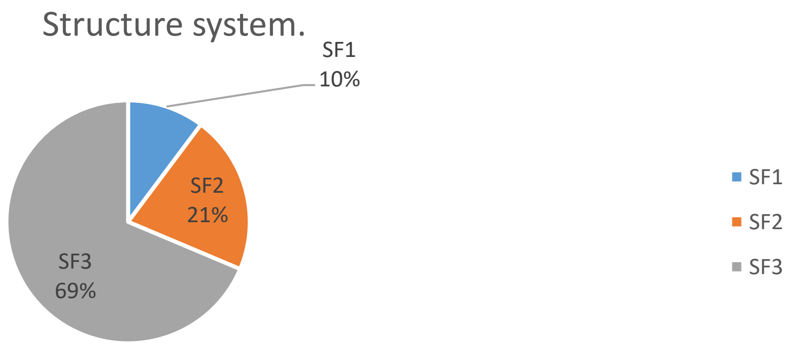


Figure 1: results of F-AHP of Medical system

Factor	Rank %
SF1	10%
SF2	21%
SF3	69%



is in the building operations field. It is important to note that fuzzy applications may prove to be beneficial to the construction business. In summing up, the findings of this research shed light on the difficulties associated with selecting building components. The following is the conclusion that can be drawn from this study: By utilizing the F-AHP algorithm, we were able to design a system that provides assistance with decision-making about the evaluation and selection of excellent gemstones in an accurate and efficient manner. Because it is impossible to compare one stone with stones of different types, not in the same class quality, the end result of the system is based on the classification of the type of stone name, which is why the focus on the decision of the system is more on the decision of stones based on the same type of stone name. This is because for the decision system to be more appropriate and relevant for use as a consideration in decision-making, the decision system must be more appropriate and relevant for

use as a consideration in decision-making. The goal of lean construction is to maximize productivity. Owners of construction companies ought to be concerned about it since it has the ability to save their companies both money and time. The goal of lean construction is to cut costs by enabling construction crews to finish tasks more quickly while wasting less resources (including time, labor, and materials). After the economic downturn has been overcome, this is of the utmost significance to building enterprise

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