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Synergies between Lean Construction and Sustainability

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Abstract: Sustainability and environment preservation is a crucial issue that has its great impact on construction industry, many researches were done how to achieve sustainable design [1]. According to literature review for sustainable project, they didn't succeed to maintain the project baseline for cost, schedule and quality a new management tool were adopted to enhance the performance of sustainable project lean construction tool. The aim of the paper is to search the common concepts and aspect between lean construction and sustainability, how to apply these concepts on the design development phase of a LEED certified project, specifically the unique and the important role of the design development phase in project, thus many of the crucial decisions are made in this phase more than any other phase [2].

The study indicated that applying lean construction management approach in design development phase of LEED certified project could improve and maintain on the cost, schedule and quality baseline of the project, it also reduces the associated risk on the design efficiency, LEED accreditation and enhance post occupancy "operation process".

Keywords: Sustainable Design, LEED Certified Buildings, Lean Construction, Lean Design, Lean Approaches

1. INTRODUCTION

Sustainable project specifically LEED certified project is characterized by its complexity nature, during the project phases. Which lead to the failure of these projects to maintain the targeted baseline of cost, schedule and quality and also to maintain its high requirements in energy conservation during operation [3].

Accordingly, there has been an intensive increase in the methodology of managing LEED certified project, through analyzing the challenges facing this type of projects [4].

Some studiesindicatedthat the ordinary management adopted towards this project will always fail to achieve the project target due to the reactionary approach followed in the conventional project management adopted that allow the problem to happen then begin to analyze, deal with it[5]. So lean construction management tool is adopted in this paper to investigate it common concept with sustainability and how to be applied on sustainable projects[6].

2. AIM OF THE PAPER

The aim of the paper is to investigate the common concepts between lean construction and sustainability aspects. Then apply the resulted tools on LEED Gold certified project, To enhance the performance of LEED certified projects that promote for sustainability.

3. METHODOLOGY

The Methodology of this paper started with data collection related to common concepts between lean construction and how to apply this methodology on LEED certified projects in order to accomplish sustainability in the construction industry; Lean principles, tools were highlighted also sustainability aspects were mentioned. Then, a case study was conducted on a LEED Gold certified project, to assess the impact of lean construction on design development phase of this project, acting on six factors cost, time, quality, Design efficiency, LEED accreditation and finally operation process.

4. SUSTAINABILITY &LEAN CONSTRUCTION OVERVIEW

There are several ways in which the principle of sustainability is integrally linked to lean construction, and it is advantageous to use lean construction methods to be adopted in sustainable buildings with minimizing waste and maintain the project cost baseline, it is also vital to develop design development phase in such a way that could perform in a way that encourages the long-term conservation of resources. When lean construction. uses supply chain management and just in time methods for example, as well as open information sharing among all stakeholders involved in the production process, it increases value and decreases waste [7].

Another relationship is that both sustainable development and lean approaches necessitate the same independent auditing and periodic assessment practices[8]. Furthermore, the lean concentrate on waste removal necessitates efficient systems to decrease the formation of unwanted activities.

Non-value items are eliminated. The main concepts of lean constructioninclude increasing flow activities and making transition activities more productive. It is obvious that incorporating the lean concept into a design developmentprocess will immediately improve or add to the sustainability effectiveness of the project when implemented in this manner.[9]

The basic of lean constructionprincipal, is to generate more with less.The advantages and disadvantages of lean and eco-sustainable programs lead to a hopeful conclusion: both are theoretically great complementary with the potential to drive sustainability ahead synergistically if properly linked. Lean highlights and employs the same key ideas as environmental sustainability programs. [10].

The lean constructiongoal of waste minimization aligns seamlessly with sustainability activities. In theory and practice, the sustainability effort is similar to lean; sustainability may be viewed of as lean stretched to a much wide view. Sustainability and lean are comparable in that they both emphasize closed-loop cycle reasoning rather than linear, target thinking. In addition, it continues to include comprehensive system theory, which encourages individuals to consider the long-term consequences of their actions[11].

4.1. Sustainability Aspects

As a result of the combination of social and environmental issues, an altogether new element evolved. Essentially, this characteristic focuses upon the responsibility of all individuals to a proportionate share of the ecosystem's environmental assets. Ultimately, the purpose is to avoid a portion of community from abusing these natural resources [12].

The connection between the economic and social components of sustainability results in the economic–social aspect of sustainability being formed. This element is concerned with ensuring economic sustainability while without threatening the requirements of society. This could be accomplished by the promotion of business ethics, the assurance of fair trade, and the protection of worker's rights [13].

This connection resulted in the development of a new facet that focuses on accomplishing environmental sustainability targets in an economically feasible manner. The reduction of superfluous costs as well as the effective utilization of energy and natural resources are required to accomplish this [14].

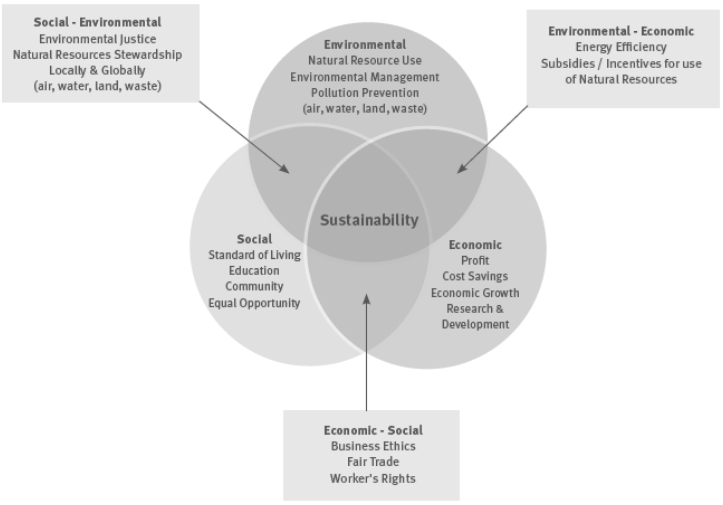

Fig 1 Sustainability Aspects [15]

4.2. Lean Construction Aspects

All of the discovered concerns related to lean in design and construction get a sensitivity rating more than 70%, implying that all of the challenges are significant. The lean construction. concept has the ability to advance the incorporation of design development phase and outcome result LEED certified building [16].

The lean construction development side has received the most of the attention thus far, with less emphasis placed on the lean design challenges. A growing amount of attention is being paid to lean design concerns, it is being addressed how to integrate the sustainable design and development phases from a lean construction approach. There has been less discussion and investigation into the implementation of lean in design due to a lack of a uniform definition. [17].

Integration in design is defined as the process of implementing work strategies, techniques, and actions that promote a framework of productive and impactful co - operation across companies and communities. According to the International Organization of lean construction, a Project Team is an integrated, an immensely impactful and productive cooperative group engaged in the development and construction of a large-scale, multi-disciplinary project, according to the International Organization of lean construction[18].

Value Principle Emphasis is on identity as well as understanding and anticipating the requirements and desires of customers. Understanding possible factors that can influence consumer choice, as well as identifying potential options as well as the most cost-effective method to fulfil client demands, among additional goals of the program.

Value Stream: Process diagrams that generate items or resources that function The satisfaction of the client, depending on if the work is carried out correctly and in the methodical timing. (1) The removal of unnecessary non-benefit actions; (2) the assessment of actions in order to decrease non-value-added actions to the greatest extent practical; and (3) the constant improvement of value-added activities are some examples of

activities that can be specified.

Flow principle The aim is to keep the process flowing smoothly through one added value to the next without interruption. Any endeavor must be made to remove obstacles that are preventing the workflow from moving forward at a faster rate with each procedure.

Pull theory Basically, it creates a standard for the ordered stuff. Research is being driven in organizations that are not lean. The majority of lean providers adapt to the needs of their customers, react to alterations, and progress the program forward.

Theory of perfectiontries to incorporate as much detail as feasible but in the most appropriate approach. Those steps are important in a current approach because it is competent feasible, it generates the expected consequences, not simply the required output, frequently, adequate, scalable, and always connected by a constant flow. If either of these factors is not required, the other is. Perfection is a process that is constantly improving, and lean firms will aim to achieve quality and productivity in the improvement of operating actions.

5. THE RELATIONSHIP BETWEEN LEAN CONSTRUCTION& SUSTAINABILITY

The natural resources should be used by the present generation in order to attain their objectives and meet their requirements. When these resources are used inefficiently, however, future generations will be unable to meet their own requirements. Consequently, there must be an exchange between current constructions that provide high comfortability and those that use resources and cause environmental harm. In order to be more sustainable, the construction industry must adopt from other sectors, like as manufacturing, that have succeeded in maximizing consumer values while reducing inefficient use of resources (including cost and time) [19].

In that approach, usage of lean principles will be advocated as a beneficial method of raising the efficiency and performance of an organization. A matrix based on studies into lean principles purposes and also principles of sustainability was developed, which was used to describe the relationship between the two domains, as well as the role of lean principlesin achieving sustainability, by the researchers [20].

For example, by using Value Concept, the development team can establish a design that meets the demands of the client while simultaneously eliminating waste in terms of process, materials, time, and effort. Correct recognition of the client and comprehension of project needs are essential for the project crew to achieve a product that meets the demand of the consumers while reducing waste in terms of materials, time, and effort. Furthermore, the Value principle aids in the selection of the most appropriate method of delivering the client requirements in a lean fashion.The Perfection principle is yet another illustration of the importance of lean principlesin establishing long-term sustainability in the building industry. This principle is concerned with empowering project teams and preparing them to carry out their assigned responsibilities in order to produce the customer's product. Additionally, it aids in the improvement of performance through the use of suitable delivery tactics, the assimilation, retention, and sharing of knowledge, as well as the implementation of corrective measures and the application of acquired lessons. To make matters better, Perfection basic concept demands that all levels of an institution adhere to the lean principlesand procedures while striving to accomplish continuous progress in terms of achieving perfection[21, 22]

5.1. Concluded Matrix

From the previous literature we could conclude the following matrix

Table 1 Matrix between L.P & Sustainability Aspects[23]

Lean Concepts	Methodology to achieve sustainability by Lean	Sustainability Aspects					
		Environmental Aspect	Economical Aspect	Social Aspect	Environmental-Economic Aspect	Economic-Social	Social-Environmental
Concept of Value	Recognizing the prospective client's objectives, needs, and restrictions is essential to successful implementation process.	√	√	√	_	_	_
	Identified waste must be removed or reduced in order to have a positive impact.	√	√	_	_	_	_
	It is necessary to evaluate the influence of internally and externally aspects that influence a client 's decision and to seek alternate answers that can be modified to accommodate modifications without incurring significant costs in terms of Schedule, cost, or effort.	√	√	√	√	√	√
	Increasing the efficiency, result, and value of the endeavor to the greatest extent possible.	√	√	√	_	_	_
	Choosing the most suitable method of delivering the client's expectations is an important decision.	√	√	√	√	√	√
Concept of Value Streaming	Identifying all of the tasks and resources that are essential for the phase.	√	√	√	_	_	_
	Work standardization, recurrence are all methods of improving the substance of activity.	_	√	_	√	_	_
	Identifying and sourcing crucial element vendors.	_	_	_	√	_	_

Lean Concepts	Methodology to achieve sustainability by Lean	Sustainability Aspects					
		Environmental Aspect	Economical Aspect	Social Aspect	Environmental-Economic Aspect	Economic-Social	Social-Environmental
	Organizing and arranging task, methods, and manpower to ensure that the project is completed as efficiently as possible.	√	√	√	√	√	√
Flow Concept	Activity scheduling, staff equilibrium, and work - in - progress minimization are all concepts that have been used.	√	√	√	√	√	√
	Increasing work flow and activity structure to shorten the lead times of a given operation.	_	√	_	√	_	_
	Establishing KPIs and evaluating performance are two important tasks.	_	√	_	√	_	_
	Displaying key data regarding the task, such as the timeline, budget, safety, quality and efficiency required.	_	_	√	√	√	_
	Combining all elements of just-in-time delivery while reducing the transportation and rearrangement of resources is the goal.	_	√	√	√	√	_
Pull Concept	Maintaining the operating system's flexibility and adaptability to changing client demands and upcoming modifications.	√	√	√	_	_	_
	A significant attempt to reduce lag and schedules is being made.	_	√	_	√	_	_
	Optimizing workload by controlling the influence of design on the capacity to attain lean performance is a key component.	√	√	√	_	_	_

Lean Concepts	Methodology to achieve sustainability by Lean	Sustainability Aspects					
		Environmental Aspect	Economical Aspect	Social Aspect	Environmental-Economic Aspect	Economic-Social	Social-Environmental
Perfection Concept	Stakeholders in projects are empowered to contribute to providing optimum value to clients, eliminating waste, and achieving continual development in both organization and project efficiency by being involved in the project.	√	√	√	√	√	√
	Learning and coaching project managers in order for them to fulfil their assigned duty of providing client needs is essential.	√	√	√	√	√	√
	In order to increase system development throughout the firm, information must be assimilated, retained, and transferred easily.	√	√	√	√	√	√
	Adopting proactive acts in response to flaws while also keeping such options for potential application	√	√	√	√	√	√
	Making all management ranks and inspection accountable for sticking to the concepts and practices of lean implementation and continual development.	√	√	√	√	√	√
	In order to optimize the delivery of lean projects, the 5s should be implemented.	√	√	√	√	√	√
	Reporting and comprehending all important work procedures carried through project team is a top priority.	√	√	√	√	√	√

6. ASSESSMENT OF LEAN CONSTRUCTION ON LEED CERTFIFED PROJECTS

Most previous research concentrated on waste generated by actual construction operations and examined it as a case for improvement using lean concepts.According to previously conducted research, the design developmentphase of building projects have a major effect on the risk and final value of the project [24]. design developmentphase is frequently considered in terms of its involvement in waste generation/prevention. When it comes to LEAN CONSTRUCTION methodology, waste items refer to any and all inefficiency, non-adding value in the process [16].

The number of actions that should be undertaken during design development phases is significantly greater than that in any other phase. The use of a lean construction methodology throughout the design developmentphase, as a result, is regarded to have the potential to improve the entire productivity of this important phase [25]. It is the goal of this research to identify and eliminate lean waste items from this phase.

6.1. Hypothesis Verification Steps.

Although lean thinking is important in improving the efficiency of sustainable design processes, the relationship between lean thinking and sustainable design processes is underappreciated based on the literature review on lean thinking. The design industry has clearly indicated that inefficiency must be reduced and the overall quality of the design development process must be raised [26].

In order to obtain maximum performance of the sustainable design developmentprocess, it is critical to improve the maturity of lean construction understanding [27]. According to the lean literature, the first phase consists in the identification of inefficiencies that act as barriers in the design development phase and are then eliminated. With this study, the researchers hope to evaluate and identifylean design waste item as well investigate their frequency of occurrence and impact on project value elements [28]. It is envisaged that the collection of such data will result in a lean design waste itemwhich will include effect degrees.

G**rounded theory** approach was integrated in order to base the study's results directly on the opinions of specialists with the least amount of subjective influence from the researcher. The phrase grounded theory refers to a theory that emerges from data that has been methodically collected and examined during the research process [29].

According to the method's structure, the trinity of information gathering, information assessment, and ultimate hypothesis is highly related to one another. Researcher also doesn't have a preconceived notion in mind before he or she begins a study. The researcher rather outlines the topic under investigation and then enables the evidence to prove or disprove his idea. One school of thought holds that a theory developed from evidence is more accurate than a hypothesis derived from a collection of conceptual experiences or solely from fiction [25]. According to the authors, statistics theories are capable of presenting internal perspective, enhanced knowledge, and appropriate direction for future action because they are open to new insights, expanded understanding, and reasonable counsel for future action [29].

6.1.1. Preliminary Interviews

A structured interview with each project stakeholder was done in order to gather the information needed for the design of the questionnaire. The primary intention was to compile list of waste items associated with lean design. The waste concept in this part appears to be an internalization of the lean thinking definition of waste.

6.1.2. Challenges Impact Results

Following the collection of information on the issues faced by each project throughout the design development phase, a further survey with the same stakeholders was held.

The goal of the survey was to have a better understanding of the influence of these obstacles on project parameters (Cost-Schedule-Quality) and also the mitigate the risk of these challenges and their impact on 3 specified factor in this study which are Design Efficiency, LEED Accreditation, Operation (Post Occupancy Satisfaction).

For statistical purposes, it is necessary to establish the risk factor associated with each waste item discovered during the interviews. As mentioned above, risk is an unanticipated event that can be construed both as a threat and as a possibility, this can have both negative and positive repercussions. Two components comprise the risk idea: uncertainty (represented as the probability of occurring) and affect (stated as the consequences of event happening) (specified as impact). It is asserted that the risk may be efficiently assessed by accurately estimating the event's likelihood and effect. The scientific formula "R = I x P" can be written as "R = I x P." Where "R"

represents the risk rating, "I" represents the effect magnitude, and "P" represents the likelihood of occurrence[30]

Taking into consideration the numerous ramifications and unpredictability associated with the waste items mentioned in this research, it is possible to establish a statistically significant relationship between the waste items presented in this study and the risk concept [31]. This phase does not aim to gather absolute statistics on their probability or impact percentages, but rather to establish a risk that is worthy of ranking among waste items in terms of its potential impact.

6.1.3. Lean Construction Management Implementation

After deciding on a waste category, the origins for each challenge was matched by its corresponding category according to lean construction waste identification. Then determine Lean approach to deal with type of waste, Lean methodology was then adopted based on lean approach, finally the action need from project managers.

6.1.4. Results

The study assumed a theoretical percentage improvement for each project, so we can compare between the mentioned above parameters before and after adopting lean construction management in accordance with the original formula "R = I x P," a grade is assigned to assess the effectiveness of every one the six categories under consideration. A risk rating is represented by "R," an impact magnitude is represented by "I," and a possibility is represented by "P.". Then a comparison is made before and after adopting lean construction methodology to highlight the impact of improvement[30].

7. HSBC HRADQUARTER CASE STUDY

The building comprises 2 basements 4,500 m2 each, ground floor 3,125 m2, 4 typical floors 3,125 m2 each & roof floor 680 m2. Total built-area of 25,305 m2. This building was accredited for LEED Gold certificate with 44 points.Hence all this major features the project didn’t succeed to achieve the planned schedule, over budget, also studies confirms that the project doesn’t comply with all LEED requirements assed by the project when it was recently finished, which mean there is a bad management in the operation process.

Fig 2 HSBC Headquarter in Smart Village

7.1. Preliminary Interviews

Interviews were conducted with the project consultant and project management consultant, to stand on the challenges faced in design development phase, then after collecting the challenges mentioned by them, it was resubmitted to them to assess the challenge on the project parameters (Cost, Schedule & Quality) also to assess the impact on Design Efficiency, LEED Accreditation & Building Operation.

Table 2DESIGN DEVELOPMENT. Challenges

Design Development phase challenges						
Challenge Description	Project Value Parameters			Impact		
	Cost	Schedule	Quality	Design Efficiency	LEED Accreditation	Operation
Review data from other disciplines	√	√	√	√	√	_
Problem with project stakeholders	_	√	√	√	_	√
Problems with governmental procedures	_	√	√	√	√	_
Rework	√	√	_	√	_	_
Previous work that took a long time	√	√	_	_	_	_
Requesting related disciplines' inputs	_	√	_	√	_	_
Delayed customer feedback	_	√	_	√	_	√
Lack of corporate behaviors	_	_	√	√	_	_
employee innovation disregarding	_	_	√	√	√	_
Ineligible other discipline information	_	√	√	√	_	√
Improper engineering designs, dwgs& specifications.	_	_	√	√	_	_
Architectural decision alterations	√	√	_	√	√	_

7.2. **Frequency and Impact Evaluation.**

A secondary interview was conducted to stand on the impact of the challenges on the six factors mentioned as follows:

Table 3DESIGN DEVELOPMENT Challenges Frequency & Impact

Design Development phase challenges							
Challenge Description	Frequency of occurs	Project Value Parameters			Impact		
	Frequency Mean	Challenge Impact on Cost Parameter	Challenge Impact on Schedule Parameter	Challenge Impact on Quality Parameter	Risk Value on Design Efficiency	Risk Value on LEED Accreditation	Risk Value on Operation
Review data from other disciplines	2.60	2.01	2.26	2.15	4.00	9.00	_
Problem with project stakeholders	2.58	_	2.33	2.85	8.84	_	6.34
Problems with governmental procedures	2.35	_	2.57	2.39	5.28	3.71	_
Rework	2.73	2.33	2.64	_	5.55	_	_
Previous work that took a long time	2.55	2.69	2.16	_	_	_	_
Requesting related disciplines' inputs	2.41	_	2.55	_	7.24	_	_
Delayed customer feedback	2.42	_	_	2.22	3.90	_	9.66

Design Development phase challenges							
Challenge Description	Frequency of occurs	Project Value Parameters			Impact		
	Frequency Mean	Challenge Impact on Cost Parameter	Challenge Impact on Schedule Parameter	Challenge Impact on Quality Parameter	Risk Value on Design Efficiency	Risk Value on LEED Accreditation	Risk Value on Operation
Lack of corporate behaviors	2.48	_	_	2.68	_	_	_
employee innovation disregarding	2.14	_	_	2.08	9.71	7.71	_
Ineligible other discipline information	2.86	_	2.42	2.56	3.56	_	8.48
Improper engineering designs, dwgs& specifications.	2.45	_	_	2.42	4.93	_	_
Architectural decision alterations	2.42	2.17	2.13	_	4.14	3.58	_

7.3. Lean Construction Management Implementation

The challenges were sorted and categorized according lean construction waste types, then lean construction method was applied in addition to the required action from the project manager as follows:

Table 4 Applying lean construction on design development Challenges

Design Development phase challenges				
Challenge Description	Challenge Waste Type	Lean Approach	Lean methodology Adopted	Action Needed
Review data from other disciplines	Deficiencies / Correction	Flow Process Approach	Reduce cycle time/Reduce batch sizes	Flow of information between project parties/Implementation of regular quality internal audit
Problem with project stakeholders	Over processing	Flow Process Approach	Reduce Process Variability/Increase flexibility	Flow of information between project parties
Problems with governmental procedures	Over processing	Flow Process Approach/Continuous Improvement	Increase flexibility	Flow of information between project parties
Rework	Over processing	Flow Process Approach	Reduce cycle time/Reduce batch sizes	Weekly workload planning & performance monitoring/Implementation of regular quality internal audit
Previous work that took a long time	Waiting	Flow Process Approach	Reduce cycle time/Reduce batch sizes	Weekly workload planning & performance monitoring/Implementation of regular quality internal audit
Requesting related disciplines' inputs	Waiting	Flow Process Approach/Pull Approach	Reduce cycle time/Just in Time	Flow of information between project parties/Supervisors to plan their workload on weekly basis
Delayed customer feedback	Waiting	Flow Process Approach/Pull Approach	Reduce cycle time/Just in Time	Flow of information between project parties
Lack of corporate	Over processing	Continuous Improvement	Operation Improvement	Implementation of regular quality internal audit

Design Development phase challenges				
Challenge Description	Challenge Waste Type	Lean Approach	Lean methodology Adopted	Action Needed
behaviors				
employee innovation disregarding	Unused Employee Creativity	Continuous Improvement	Process/Operation Improvement	Weekly workload planning & performance monitoring/Implementation of regular quality internal audit
Ineligible other discipline information	Over processing	Flow Process Approach/continuous Improvement	Reduce Batch Size/ Operation Improvement	Weekly workload planning & performance monitoring/Implementation of regular quality internal audit
Improper engineering designs, dwgs& specifications.	Deficiencies / Correction	Flow Process Approach/continuous Improvement	Reduce Batch Size/ Operation Improvement	Weekly workload planning & performance monitoring
Architectural decision alterations	Deficiencies / Correction	Flow Process Approach	Reduce Process Variability	Weekly workload planning & performance monitoring/Implementation of regular quality internal audit

7.4. Results after implementing lean construction management

The study assumed 20% implementation for LEAN CONSTRUCTION methodologies which will have impact on the frequency and challenges impact as follows:

Table 5LEAN CONSTRUCTION Impact on DESIGN DEVELOPMENT Challenges

Design Development phase challenges After Adopting Lean Methodology							
Challenge Description	Frequency of Occurs	Project Value Parameters			Impact		
	Frequency Mean	Challenge Impact on Cost Parameter	Challenge Impact on Schedule Parameter	Challenge Impact on Quality Parameter	Risk Value on Design Efficiency	Risk Value on LEED Accreditation	Risk Value on Operation
Review data from other disciplines	1.83	2.03	1.90	2.08	6.23	6.27	_
Problem with project stakeholders	2.08	_	2.04	1.61	4.94	_	3.92
Problems with governmental procedures	2.11	_	1.68	2.06	3.89	6.11	_
Rework	1.53	2.09	2.15	_	4.94	_	_
Previous work that took a long time	2.09	1.91	1.58	_	_	_	_
Waiting for information from other disciplines	2.02	_	1.72	_	6.00	_	_
Late information from client	1.68	_	_	1.56	6.33	_	4.20
Incapability to have institutional	1.67	_	_	1.88	_	_	_

Design Development phase challenges After Adopting Lean Methodology							
Challenge Description	Frequency of Occurs	Project Value Parameters			Impact		
	Frequency Mean	Challenge Impact on Cost Parameter	Challenge Impact on Schedule Parameter	Challenge Impact on Quality Parameter	Risk Value on Design Efficiency	Risk Value on LEED Accreditation	Risk Value on Operation
habits							
Unused employee creativity	1.67	_	_	1.67	7.21	5.91	_
Unqualified data from other disciplines	2.04	_	1.56	1.72	2.58	_	4.25
Production of defective technical drawings & details etc,	2.10	_	_	1.70	5.37	_	_
Architectural decision alterations	1.66	1.61	1.62	_	6.89	2.46	_

7.5. Case Study Conclusion

Finally, the research compared between results before and after applying lean construction methodology to figure out the influence of lean construction methodology on enhancing design development phase of a LEED certified project as follows:

Table 6 Comparison between Project Parameters before and after Lean Construction Adoption

	Before Adopting Lean	After Adopting Lean	% of Improvement
Challenge Impact on Cost Parameter	2.48	1.07	43.15%
Challenge Impact on Schedule Parameter	3.09	1.11	35.92%
Challenge Impact on Quality Parameter	2.74	1.20	43.80%

Table 7 Comparison between Selected Factors before & after Lean Construction Adoption

	Before Adopting Lean	After Adopting Lean	% of Improvement
Risk Value on Design Efficiency	5.96	3.20	53.69%
Risk Value on LEED Accreditation	7.22	3.87	53.60%
Risk Value on Operation	7.04	2.96	42.05%

8. CONCLUSION

No doubt about the necessity of taking serious steps towards more sustainable environment through construction industry. Conventional management approach failed to achieve the targets of sustainable project, so a new management approach should be adopted. Lean construction approach when adopted had achieved common concepts between lean construction and sustainability, successes in managing the design development phase of LEED certified projects, which open the research work open to the researches to investigate more about applying lean construction approaches in different phases.

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