

Reinventing Lean: An Optimized and Adaptive Approach to Construction Efficiency

Mrinmoyee Bhattacharya¹

¹Assistant Professor, Department of Computer Science, St. Xavier's University, Kolkata, Kolkata, 700160, West Bengal, India, mrinmoyee.bhattacharya@sxuk.edu.in

Abstract - Optimization is important for any kind of process which can only be accomplished following a structured approach. A lean approach guides towards the maximization of payback as well as minimization of the misuse. A lean construction management emphasizes on monitoring and continuous quality improvement for the best possible output. In our study, we have identified the key components for the lean construction management to examine how these could be used to achieve optimized output.

Key Words: Lean, Optimization, Management, Construction, Output

1. INTRODUCTION

Lean Construction is an immediate measureable output based production system. In this process, there are number of key areas which may include but not limited to certain activities or functions like: (A) Appropriate approach for Project Delivery on Schedule and Process Flow (B) Collaboration/Relationship Management with respects (C) Generation and Preservation of the Values (D) Removal of Waste and Disposing the same maintaining the categories during the Project Life Cycle.

Lets us take Lean Construction Management Indicator (LCMI) as Y where $Y=f(x)$, then we can write $f(x) = f(X_1) + f(X_2) + f(X_3) + f(X_4)$ presuming X_1, X_2, X_3 and X_4 as some variables which can be presented as :

A	B	C	D
X_1	X_2	X_3	X_4

In this relationship model, function $f(X_2)$ to .. $f(X_4)$ all are dependent on $f(X_1)$ that means if approach to the project delivery and its flow is not defined, no matter whatsoever we do, any good output and/or optimization cannot be achieved.

In calculus, range represents set of all possible values of a function, the set of input values are the domain of a function. Let us define the ranges with respect to the secondary sources:

Function Range	Description	Condition	Reference for the value
$0 \geq f(X_1) \leq 0.4$	A: Delivery planning and Project Flow	$F(B,C,D)=F(A)$	[1]
$0 \geq f(X_2) \leq 0.1$	B: Collaboration/Relationship Management	$F(A) > 0$ or $f(X_1) > 0$	[2]
$0 \geq f(X_3) \leq 0.2$	C: Value Management	$F(A) > 0$ or $f(X_1) > 0$	[3]
$0 \geq f(X_4) \leq 0.30$	D: Removal of Waste	$F(A) > 0$ or $f(X_1) > 0$	[4]

Relationship Model: Entity (B),(C) and (D) is fully dependant on entity (A) that means if $f(X_1) > 0$ then only the other entities (B),(C) and (D) to be considered. That mathematically means,

(1) $f(X_2), f(X_3)$ and $F(X_4)$ can have a finite value 0 or more if $f(X_1) > 0$

(2) $f(X_2) = 0, f(X_3) = 0$ and $F(X_4)=0$ when $f(X_1)=0$

2. Literature Review

The construction industry faces constant pressure to improve project efficiency, reduce waste, and increase profitability. Various studies and reports highlight key factors influencing these outcomes, including planning strategies, value management, and lean practices. Research by [1] emphasizes the significance of effective project planning in enhancing contractor profitability. The study identifies that meticulous planning contributes to better resource allocation, time management, and cost control, ultimately leading to improved financial performance. Similarly, a report available on [2] investigates construction project performance in terms of risk, schedule, and quality. It underlines that planning alone is not sufficient; integrated project delivery and proactive stakeholder involvement are crucial to maintaining project success throughout its lifecycle. The application of value management is another critical element discussed in the literature. According [3], value management is a structured approach that ensures client requirements are met without unnecessary cost escalation. The technique is particularly effective in

identifying value-adding functions and eliminating superfluous expenditures, leading to cost-efficient and client-satisfactory projects. Furthermore, waste management and sustainability are also prominent concerns. This Paper [4] provides insights into the environmental impacts of construction waste and the importance of implementing lean construction techniques to mitigate these effects. The resource highlights that by minimizing waste and maximizing resource efficiency, construction companies can not only reduce environmental footprints but also gain economic benefits. Collectively, these studies underscore the importance of integrated planning, value-driven processes, and sustainability practices in achieving optimal performance in construction projects.

3. Methodology

A quantitative method has been adopted for our study. Initially, the key components are defined which could be used as functions by tabulating their ranges and domains as well as the relationships. Range indicated the approximate values obtained from the secondary sources. Different use cases were then examined using elementary mathematics and calculus.

4. Result

arg max also represented as argmax returns the maximized values of the given functions, similarly, arg min also represented as argmin returns the minimized values of the given functions,

We know:

$$f\left(\arg \max_x f(x)\right) = \max_x f(x)$$

$$\text{So, } f(\arg \max_x f(x)) = \max_{x_1, \dots, x_n} f(x_1 + x_2 + \dots + x_n)$$

Where n = 1 to 4

$$\text{When, } f(x_1) > 0, \text{ we get } f(\arg \max_x f(x)) = 0_{x_1, \dots, x_n}$$

$$\text{When } f(x_1) < 0, \text{ we get } f(\arg \max_x f(x)) = 0_{x_1, \dots, x_n}$$

Now, let us consider arg min:

$$\text{When } f(x_1) < 0, \text{ we get } f(\arg \min_x f(x)) = 0_{x_1, \dots, x_n}$$

$$\text{When } f(x_1) > 0, \text{ we get } f(\arg \min_x f(x)) = 0_{x_1, \dots, x_n}$$

That means, 100% optimization is possible when the max values of the given functions are returned or in other words, the work is done under the ideal condition.

We can re-examine the same using calculus as below:

Let us calculate f(x) under different conditions.

Case 1:

$$f(x) = \text{Limit } f(X_1) + f(X_2) + f(X_3) + f(X_4) = 0 \quad A \rightarrow 0$$

Observation: No optimization can be reached without Proper Plan and Process Flow because B,C,D are dependent on A.

Case 2:

$$f(x) = \text{Limit } f(X_1) + \text{Limit } f(X_2) + \text{Limit } f(X_3) + \text{Limit } f(X_4) = 0.4 \quad A \rightarrow 0.4 \quad B \rightarrow 0 \quad C \rightarrow 0 \quad D \rightarrow 0$$

Observation: If Proper Plan and Process Flow exists even other functions remain non-existent, optimization at 40% level is achievable.

Case 3:

$$f(x) = \text{Limit } f(X_1) + \text{Limit } f(X_2) + \text{Limit } f(X_3) + \text{Limit } f(X_4) = 0.6 \quad A \rightarrow 0.4 \quad B \rightarrow 0.2 \quad C \rightarrow 0 \quad D \rightarrow 0$$

Observation: If Proper Plan and Process Flow exists along with collaboration/Relationship management, optimization at 60% level could be achieved.

Case 4:

$$f(x) = \text{Limit } f(X_1) + \text{Limit } f(X_2) + \text{Limit } f(X_3) + \text{Limit } f(X_4) = 0.7 \quad A \rightarrow 0.4 \quad B \rightarrow 0.2 \quad C \rightarrow 0.1 \quad D \rightarrow 0$$

Observation: If Proper Plan and Process Flow exists along with collaboration/Relationship and value management optimization at 70% level could be achieved.

Case 5:

$$f(x) = \text{Limit } f(X_1) + \text{Limit } f(X_2) + \text{Limit } f(X_3) + \text{Limit } f(X_4) = 1.0 \quad A \rightarrow 0.4 \quad B \rightarrow 0.2 \quad C \rightarrow 0.1 \quad D \rightarrow 0.3$$

Observation: If Proper Plan and Process Flow exists along with collaboration/Relationship, value management and Waste removal optimization at 100% level could be achieved.

Table1: Function values for different ranges of X_i

Range	Fun(X_1)	Fun(X_2)	Fun(X_3)	Fun(X_4)	Fun(X)
Min	0	0	0	0	0
Mid	0.2	0.1	0.05	0.15	0.5
Max	0.4	0.2	0.1	0.3	1

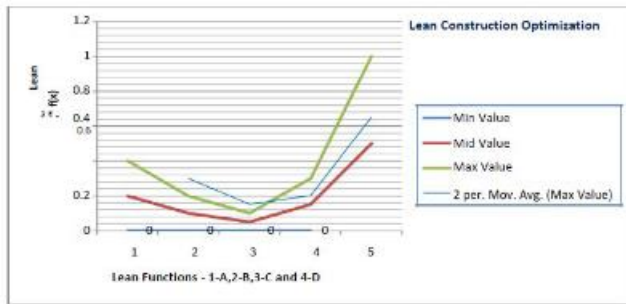


Fig -1: Lean Construction Optimization: Function values and moving averages for functions A (1),

B (2), C (3), and D (4)

(1) When all the functions of A,B,C and D are minimum, especially when A is min $Y = f(x) = 0$

(2) With all mid values of A,B,C and D at least 50% optimization possible

(3) For any value of A above the mid value, at least 60% plus optimization is possible (by Moving Average)

(4) With all max values for A,B,C,D ,100% optimization is possible

5. CONCLUSION

The secondary sources indicate values for (A) → 43 to 50%, (B) → 22.1% to 23.7%, C→10 to 25% and D→30%. For the purpose of our study, we have taken the following values: A→40%, B→20%, C →10% and D→30%. More granular level study and analysis is possible which is not done by us in this paper. For example, from project management perspective component (A) which represents „Appropriate approach for Project Delivery on Schedule and Process Flow“ could be divided into many sub-components like (A₁) Work Break Down Structure (WBS), (A₂) Budget (A₃) Scope (A₄) Resource Procurement (A₅) Delivery Schedule (A₅) Quality Control Process. Component B which represents “Collaboration/Relationship Management with respects” can be broken into sub-components like (B₁) Mode of Communication (B₂) Lead Management (B₃) Use of Analytics for Customer Satisfaction etc. Component C which represents “Value Management” could be broken into (C₁) Functional Analysis (C₂) Bench Marking of Values (C₃) Target Cost Profiling etc. Component D which represents “Removal

of Waste and Disposing the same maintaining the categories during the Project Life Cycle” could be broken into (D₁) Types of Waste (D₂) Removal Plan (D₃) Recycle Plan etc, So, instead A,B,C,D we can derive more granular elements like A₁ .. A₅, B₁ ..to B₃, C₁ .. to C₃ and D₁... to D₃ . Analysis of these using the same technique will provide more meaningful insight for the process of optimization.

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