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An Application of Lean and Six Sigma Principle for Constructional Process Improvement in Indian Organizations

KEYWORDS: Lean Construction, Competitiveness, Value Stream Mapping

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ABSTRACT *India has seen tremendous growth in construction and infrastructure sector in last decade. To achieve a double digit growth in construction sector, a continuous effort should be taken. Such a growth opportunity can be leveraged for competitiveness by adapting the principals and various tools of learn and six sigma management for min or zero wastage. Delays were rampant in construction earlier and now costs are often too high for quality that is given. With increasing competition from domestic and international construction forms innovation has raised up for the implementations, adaptation of Lean Concepts Seems to have higher potential for the construction industry.*

This paper highlights the real issues contrasting construction organizations and explores the potential of Lean and Six Sigma construction concepts in construction industry in India. Lean Construction and Six Sigma or related concepts have been successful acceptance in the Automobile sector in many countries. But still the same has yet to be used in Construction rigorously.

This paper will focus on this emerging concept called – "Lean Construction" based on the basic Principles of management and special tools and techniques to achieve those desired goals of better productivity and better profit margins.

INTRODUCTION –

Construction is one of the most important and Core industries of a nation. In order to effectively Utilization of resources available we need to properly manage the process of construction. In this way the construction management is an important and highly essential activity in civil Engineering.

Application of Lean and Six sigma methodology will provide a guideline in making the process more effective and profitable. Lean and Six sigma have both management and technical components: On management side it focuses on getting the right process and goals. The right projects and right people to work on the projects.On Technical side it focuses on enhancing process performance using process data, statical thinking and methods.Lean and six sigma methodology can be used to gain deeper understanding of construction and explore new knowdge of contempoery practices can help extend the theory of lean and six sigma to provide a deeper understanding and improvement in construction process.

In every field of industry people are making continuous efforts for improving quality of the product and enhancing the performances of the process, people and tools. Among all different alternatives "Lean" concepts seems to have higher potential for the construction industry. This paper highlights the real issues confronting construction organizations are explores the Potential of Lean construction concepts in construction industry in Dhule region of Maharashtra state in India. Lean concepts are successfully utilized in other industries. In the proposed paper research the principles of lean construction and six sigma will be applied to construction industry resulting in improving performance and better quality of the construction (Process) as well as net profit.

Apart from mega projects, the quantity of new physical assets being created has increased very rapidly. There are some remarkable achievements in quantitative terms. A Lean and six sigma methodology essentially eliminate wastage throughout the process. Waste cart you resources, but adds no value to customers you serve. These non-values added activities typically equal 95% of all manufacturing effort, a mere 5% of your activities add value for your client[1]. This is being good time to think about real competitiveness.

The current boom may have shifted focus from some inherent problems in the industry with rapidly rising prices; weaknesses in processor productivity and quality often get over looked.

Due to lots of improvement in construction process, technology, involvement of automation and equipments costs over runs were still in the range of 20% - 25%.

Cost escalation and schedule delay are major problem in construction but as compared to Govt. Projects, private Projects are much better. Cost and time over-runs are quite Prevalent there also. It needs a appropriate approach to help us solve these problems and that proven approach be "Lean and six sigma".

Lean has produced remarkable result in continuous organizations several leading companies in india have implemented concents related to lean to improve competitiveness on many organizations and factors. They get benefited. In India very few organizations know about the concept and it's implementation for continuous improvement.

Six Sigma technique is most commonly used in service sector companies but, this technique can also be successfully used in manufacturing industries. But sorry to say that Construction organizations are not using Lean & Six Sigma methodology in Civil Construction Engineering.

In Indian scenario it is observed from table 1 that the large number of industries in service sectors and manufacturing sector are using six sigma technique however a very few or nil application are absorved in construction organization hence major aim of these review to observed the methodology and application of six sigma in costruction organization . this paper present a case study of as applied to four costruction organization

Service Industry/Sector		Manufacturing Industry/Sector	
Airport Autority of India	Apollo Hospital	Addidas	Baxter India
Allsec Technology	Anz Sollutions	Bell Helicoptors –	Cadbury

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Expro Freight Pvt Ltd.	Family Health Plan Ltd.	Coco cola	D.S. Group
FMR India (Fidelity)	Gallelio India Pvt Ltd	Ducks India Ltd	Eicher
Gmac Financial Services India Pvt Ltd	Google Online India Pvt Ltd	Moser Baer	Ongc
GSS America	Icfai	Pepsi	Phillips India
I-Flex Sollution	ICICI One source	Ramco Steel Pvt Ltd	Taikisha Engineering
Info-Edge(Naukari)	Ma Foi Management Consultant Ltd	Whirlpool	Simsons
Maxc New York Life	Metlife	Subros Air-conditioning	Venus Sugars Ltd
Mid Day Multimedia Pvt Ltd	Motherson Sumi Infotech & Designs Ltd	Polygenta Technologiest	Kone Elevators
Reders digest	Defence research and development organization	MM aqvatechnology	
Refco sify	Air india Ltd.	Hindustan Gum And Chemical ltd.	
Royal sundaram alliance Insurance campany	Hutch	Tata Motors	
Rpg life sciences	Unisys Global sevices	Tecumesh India pVt. Ltd.	
Sap india pvt. Ltd	Accenture	Geetanjali gems Ltd.	
Stock hlding corporation of india	Exl	Everyday Indutires India Ltd.	
Taj group hotels	Areva T&D Pvt.Ltd	Honda Motor Cycle and scooter Pvt.Ltd.	
Tata projects	Denave India Pvt. Ltd.		
Siro clinfarma pvt. Ltd.	Keppe Purvankara Pvt. Ltd		
Spryance india pvt. Ltd	Principle Pnb Asset maneger		
Xorient Solution Pvt. Ltd.	ISg Novasoft technologies Ltd.		
Syntel Ltd.	Center for development of telematics		
Orange buissness service	Globeop Financial services india PVt. Ltd.		
State bank of india			
LIFE insurance corporation			

Table 1 List of companies who are using Six Sigma in India

This paper focuses to understand the principles. Why, what and how Dimensions, which are mostly based on secondary data. A principle related to Lean Construction and sigma indicate the benefits on cost, inventory and through put.

In spite of several efforts author could not find any case study dissipating benefits of Lean construction; however during the research period a case let was developed by author, which show's possible improvement in activity productivity to the turn of 30% Highlights of this case let are discussed the paper.

CASELETS OF "LEAN CONSTRUCTION & SIX SIGMA" IMPLEMENTATION

A case study is carried out in Dhule district in Maharashtra. A Table shows list of prestigious project and its location along with construction organization's name. So many Works are going on out of these four organization where selected based on complete availability of technical data has been taken into consideration

Sr. No.	Name of Customer	Name of Construction Organization	Location
1	Soma Construction Company		Dhule
2.	Shirpur Construction Company		Shirpur
3.	A.C.P.M. Medical College		Morane
4.	Dr. Ashish Patil		Dhule
5.	Dr. Rahul Deore		Sakri
6.	P.R. Assocate.	Mr Salunkhe Mr Vijay Patil	Dhule
7.	Dr. Jitendra Ghumare		Dhule
8	Manoja Sthapatya		Dhule
9	The Indian Humepipe Construction Ltd.		Nandale
10	P.D. Pawar Construction Company		Dondaicha
11	Gramin Rugnalaya		Songir
12	M.S.W. College of Morane		Morane
13	Magi Agro Chemicals		Sadgaon
14	K.T.Were Cum Bridge		Kumar Nagar
15	Piyush Construction Company		Dhule
16	Laxmi Construction		Dhule
17	Prerana Construction	Mr Dhananjay Patil	Dhule
18	Shri Kubera Developers		Dhule
19	Someshwar Developers		Dhule
20	Gosar Developers		Dhule
21	K.S.Wani Memorial Trust		Dhule
22	Mr. Raju Marathe	Mr. Raju Marathe	Dhule
23	P.R.Asssociates		Dhule
24	Souvenior Developers Pvt. Ltd.	Mr sanjay patel Mr kamalakar patil	Dhule

who is going to construct residential bungalow, flat system, and semi Govt.contractor work. The more details of case study is given in

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table 3.

Sr.No.	Name of the Company	Type of company	Experience	Type of Projects Handled /Project Details	Specialization in any kind of Projects	Quality Accreditation	Benefits From Lean
A	Raju Marathe	Builders & Contractor	5-7 yrs	Housing Project	Govt. Servants Schemes + Flat / Bungalow	In Process	Increase in Productivity on a expansion project Sub Contracting Profit Increased
B	P.R.Associates	Builders & Contractor	7yrs	Flat System Commercial Complex	Flat / Bungalow	In Process	Increased in productivity Lesser raw material inventory Increase in throughout
C	Soviniar Developers	Builders & Contractor	10 yrs	Readymade Twin-Bungalow	Flat / Bungalow	ISO in Process	More Satisfied Costomers Reduced Accident rate
D	Dhananjay Patil	Road / Bridges	5-7 yrs	Govt. Contract Works	Govt. Servants Schemes	NO.	Sub contracting Cost Reduced

Table 3 Details of Case-Studies

The company/organization has been working since 2004 and has achieved major results. There results and findings are described below. With a Snap Shop, we have requested them to apply the principle and tools of lean and six-sigma management in their construction activities to improve the productivity and reduce the wastage. They took the decision for applying Lean & six sigma principals. Initially Lean Construction approach was taken and it was applied on pilot projects @ Dhule site, with great results – productivity improvement in labour and equipments has seen

Methodology-

Six Sigma has two key methodologies: DMAIC and DMADV. DMAIC is used to improve an existing process. DMADV is used to create new product designs or process designs in such a way that it results in a more predictable, mature and defect free performance.

Also see DFSS (Design for Six Sigma) quality. Sometimes a DMAIC project may turn into a DFSS project because the process in question requires complete redesign to bring about the desired degree of improvement.

DMAIC

Basic methodology consists of the following five steps

1. Define the process improvement goals that are consistent with customer demands.
2. Measure the current process and collect relevant data for future comparison.
3. Analyze to verify relationship and causality of factors. Determine what the relationship is, and attempt to ensure that all factors have been considered.
4. Improve or optimize the process based upon the analysis using techniques like Design of Experiments.
5. Control to ensure that any variances are corrected before they result in defects. Set up pilot runs to establish process capability, transition to production and thereafter continuously measure the process and institute control mechanisms.

DMADV

Basic methodology consists of the following five steps:

1. Define the goals of the design activity that are consistent with customer demands and strategy.
2. Measure and identify CTQs (critical to qualities), product capabilities, production process capability, and risk assessments.
3. Analyze to develop and design alternatives, create high-level design and evaluate design capability to select the best design.
4. Design details, optimize the design, and plan for design verification. This phase may require simulations.
5. Verify the design, set up pilot runs, implement production process and handover to process owners.

- Plain observation of the process was done to explore the possibility to improve productivity.
- Factors affecting productivity were carefully studied and noted down.
- Wastage of material, its causes, and prevention methods were discussed with the site team and steps were taken to improve them.

Some people have used DMAICR (Realize). Others contend that focusing on the financial gains realized through Six Sigma is counter-productive and that said financial gains are simply byproducts of a good process improvement.

Another additional flavor of Design for Six Sigma is the DMEDI method. This process is almost exactly like the DMADV process, utilizing the same toolkit, but with a different acronym. DMEDI stands for Define, Measure, Explore, Develop, Implement.

More on Six Sigma

Six Sigma (6) is a business-driven, multi-faceted approach to process improvement, reduced costs, and increased profits. With a fundamental principle to improve customer satisfaction by reducing defects, its ultimate performance target is virtually defect-free processes and products (3.4 or fewer defective parts per million (ppm). The Six Sigma methodology, consisting of the steps "Define - Measure - Analyze - Improve - Control," is the roadmap to achieving this goal. Within this improvement framework, it is the responsibility of the improvement team to identify the process, the definition of defect, and the corresponding measurements. This degree of flexibility enables the Six Sigma method, along with its toolkit, to easily integrate with existing models of software process implementation.

Technical Detail

The primary goal of Six Sigma is to improve customer satisfaction, and thereby profitability, by reducing and eliminating defects. Defects may be related to any aspect of customer satisfaction: high product quality, schedule adherence, cost minimization. Underlying this goal is the Taguchi Loss Function, which shows that increasing defects leads to increased customer dissatisfaction and financial loss. Common Six Sigma metrics include defect rate (parts per million or ppm), sigma level, process capability indices, defects per unit, and yield. Many Six Sigma metrics can be mathematically related to the others.

The Six Sigma drive for defect reduction, process improvement and customer satisfaction is based on the "statistical thinking" paradigm:

- Everything is a process
- All processes have inherent variability
- Data is used to understand the variability and drive process improvement decisions

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As the roadmap for actualizing the statistical thinking paradigm, the key steps in the Six Sigma improvement framework are Define - Measure - Analyze - Improve - Control (see Figure 1). Six Sigma distinguishes itself from other quality improvement programs immediately in the "Define" step. When a specific Six Sigma project is launched, the customer satisfaction goals have likely been established and decomposed into sub goals such as cycle time reduction, cost reduction, or defect reduction. (This may have been done using the Six Sigma methodology at a business/organizational level.) The Define stage for the specific project calls for base lining and benchmarking the process to be improved, decomposing the process into manageable sub-processes, further specifying goals/sub-goals and establishing infrastructure to accomplish the goals. It also includes an assessment of the cultural/ organizational change that might be needed for success.

Once an effort or project is defined, the team methodically proceeds through Measurement, Analysis, Improvement, and Control steps. A Six Sigma improvement team is responsible for identifying relevant metrics based on engineering principles and models. With data/information in hand, the team then proceeds to evaluate the data/information for trends, patterns, causal relationships and "root cause," etc. If needed, special experiments and modeling may be done to confirm hypothesized relationships or to understand the extent of leverage of factors; but many improvement projects may be accomplished with the most basic statistical and non-statistical tools. It is often necessary to iterate through the Measure-Analyze-Improve steps. When the target level of performance is achieved, control measures are then established to sustain performance. A partial list of specific tools to support each of these steps is shown in Figure 1

DEFINE	MEASURE	ANALYZE	IMPROVE	CONTROL
benchmark	seven basic tool	caused and effect diagram	dsign of expriments	statictical control
base line	defects	failure mode and effect analysis	modeling	control charts
contract/Contract charter	metirces	dicision and risk analysis	tolerenceing	time service methode
konomodel	data collection forms	stastictical interference	robust design	
voice of customer	plan logistics	control chart		Non staticstical controls
voice of buissness	sampling techniques	capability		procedural adherence
qulity fuctin diployment		reliability analysis		performance management
proccess flow map		root caused analysis		pereventive activities
project a mnagement		5 whys		
management by fact		system thinging		
4 whats				

Key Observations-

Tools and Plants were not available on time, or shortage of them, due to not knowing look ahead Planning among freeness & supervisions.Haphazardly placing and store of material which leads material wastage, and increased delivery organization leads to increase Process time. Human resources were not optimally utilized which leads reduction in profit margin.Degree of success depends on how an owner of the construction time believes in this system. We find many resistances during implementations are discussed.

- **Data Compilation of Planning**

Sr. No.	Description	Company/ Construction Organization			
		A	B	C	D
1	Basis of Planning	Drawing, Thumb rules, Bill of Quantity	Drawing, Thumb rules, Bill of Quantity	Drawing, Thumb rules, Bill of Quantity	Drawing, Thumb rules, Bill of Quantity
2	Levels of Planning	Macro, Entire Planning is done in 1st stroke Micro, Different stages are prepared by bracking entire Project			
3	Type of Planning	Time Cost Material	Time Cost Material Labour	Time cost material labour equipment	Cost Labour equipment
4	Frequency of Revision	Every 15 days	3 months	3 Times in Entire Project	
5	Method of Monitoring on Site	Visual	Visual	Visit Architect	Not Planned
6	Software used for elimination of Waste	No –Planning to Use	No –Planning to Use	No –Planning to Use	No planning done

Resistance during implementation

- Resistance to change
- Difficulties ro engage Parterners
- Difficulties in Planning and control system
- Tools and plants where not available on time or some time shortage.

Out of many lean tools and techniques, following lean tools and techniques were applied.

Last Planners : Daily work plan, Weekly work plan, six week look ahead plan.

Daily meeting : Huddle meetings with foreman & supervisor.

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Lean Construction Principles	Tools & Techniques used to implement the Principle	Level of Difficulty in implementation				Brief on implementation of Lean Tools
		A	B	C	D	
Flow Variability	Standardization	Low	High	Not Implement	Medium	Standard Operating Procedure Document Cost Sheets for each activity Productivity Sheets for each activity
	Last Planner	Low	High	Not Implement	Medium	Reverse Phase Scheduling Master Schedule Preparation Six-Weeks Look ahead Weekly Work Plan Reasons for Variance(Constraint Analysis) PPC Charts
Process Variability (Define the value of a product or service from the customer's point of view)	Fail Safe for Quality	Medium	High	Not Implement	Medium	Weekly Quality Checks Weekly Safety Checks Increase awareness on Quality & Safety Procedures
Pull (Switch to demand driven system)	JIT	Medium	High	Not Implement	Medium	Deliver when Required Inventory Management
Transparency	5S	Low	High	Not Implement	Medium	Sort, Straighten, Standardize, Shine, Sustain
	Increase Visualization	Low	High	Not Implement	Medium	Put the following items on display: Commitment Charts Safety Signs & Posters Project Milestones PPC Charts
Continuous Improvement(Strive for perfection) Popularly Known as Kaizen	Huddle Meetings	Medium	High	Not Implement	Medium	All Foremen Meeting Start of the day Meeting
	First Run Studies	Low	High	Not Implement	Medium	Plan-Do-Check-Act cycle Productivity Rating–LUF Field Rating

Table 4 lean principle and lean tools

CASE A	2009	2010	2011	2012
Construction Work Done In Rs	4554128	10941310	16411965	24617947
Net Profit (NP)	494123	1198073	1846346	2845835
Material & Labour Exp	1411780	3304276	4759470	7040733
Labour Exp - 40%	564712	1321710	1903788	2816293
Material Exp - 60%	847068	1982565	2855682	4224440
Profit Ratio = NP/Construction Work Done(PR)	10.85	10.95	11.25	11.56
Expenses Ratio for Labour = Labour/Construction work Donee(ERL)	12.4	12.08	11.6	11.44
Expenses Ratio for Material = Material/Construction work Done (ERM)	18.6	18.12	17.4	17.16

Case B	2009	2010	2011	2012
Construction Work Done In Rs	6050152	13049352	19865612	30266397
Net Profit (NP)	496112	1432818	2264679	3692500
Material & Labour Exp	2057051	4110545	6003347	8928587
Labour Exp - 40%	822820.4	1644218	2401339	3571435
Material Exp - 60%	1234231	2466327	3602008	5357152
Profit Ratio = NP/Construction Work Done (PR)	8.199992	10.97999	11.4	12.2
Expenses Ratio for Labour = Labour/Construction work Done(ERL)	13.6	12.6	12.08792	11.8
Expenses Ratio for Material = Material/Construction work Done(ERM)	20.39999	18.9	18.13188	17.7

Case C	2009.00	2010.00	2011.00	2012.00
Construction Work Done In Rs	6555375.00	14075250.00	21075775.00	35256302.00
Net Profit (NP)	557206.00	1477911.00	1686062.00	2645722.00
Material & Labour Exp	2228827.00	4643676.00	6375421.00	10406509.00
Labour Exp - 40%	891530.80	1983435.00	2550168.40	4162603.60
Material Exp - 60%	1337296.20	2660241.00	3825252.60	6243905.40
Profit Ratio = NP/Construction Work Done(PR)	8.50	10.50	8.00	7.50
Expenses Ratio for Labour = Labour/Construction work Done(ERL))	13.60	14.09	12.10	11.81
Expenses Ratio for Material = Material/Construction work Done(ERM)	20.40	18.90	18.15	17.71

Case D	2009	2010	2011	2012
Construction Work Done In Rs	5895630	12595405	19595955	34595905
Net Profit (NP)	719266	1385494	2547474	5189385
Material & Labour Exp	2000451	3967552	5927776	10205791
Labour Exp - 40%	800180.4	1587020.8	2371110.4	4082316.4
Material Exp - 60%	1200271	2380531.2	3556665.6	6123474.6
Profit Ratio = NP/Construction Work Done (PR)	12.19999	10.999996	12.999999	14.999998
Expenses Ratio for Labour = Labour/Construction work Done (ERL)	13.57243	12.599998	12.099999	11.799999
Expenses Ratio for Material = Material/Construction work Done(ERM)	20.35865	18.899997	18.149999	17.699998

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Conclusions

For case A Profitability improvement up to 11.56% from10.85%,Expenses Ratio for Labour is reduced up to 11.44% from 12.4%,Expenses Ratio for Material is reduced up to 17.16% from 18.6%.for case B Profitability improvement up to 12.2% from 8.19%

Expenses Ratio for Labour is reduced up to 11.8% from 13.6%,Expenses Ratio for Material is reduced up to 17.7% from 20.39%.For Case C Profitability reduced to 7.5% from 8.5 %,Expenses Ratio for Labour is reduced up to 11.81% from 13.6% ,Expenses Ratio for Material is reduced up to 17.71% from 20.4%.Gross Margin Decreased from 2010---Not Adopting Construction Management Principles.. Similarly for case Study D Profitability improvement up to 15% from12.19% , Expenses Ratio for Labour is reduced up to 11.80% from 13.57% ,Expenses Ratio for Material is reduced up to 17.7s% from 20.35%.

Wastage in the construction industry in India is quite high and process improvement may help it become cost effective and competitive. The Wastage may gate hidden as time lapses, but ultimately looses profit or the construction first, which further lead competitiveness in construction organization. Construction organization should take inspire from software, service & automobile companies.

Lean & Six sigma which has been successfully develop to improve productivity and cut cost can be effectively apply to construction organization. In immerging scenario urgent need for scaling up and adaptation and implementation of Lean & Six Sigma Methodology in construction organization. By taking help from Lean leaders and professional in India.

The construction organization needs positive thinking and top management (i.e. Owner) supposes to start on the Lean & Six Sigma implementation journey. They have to make fundamental changes in their strategic of production, quality improvement and adaptation of new technology. Thanks for the organizations who have already started implementing lean & six sigma management tools and accepted many to explore it for competitiveness. To unlock the huge potential, leading institutes and researchers has to work hard to peculate this technology to bottom of society.

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