

LEAN SIX SIGMA PRINCIPAL IN CONSTRUCTION: A LITERATURE REVIEW RELATED TO ABSTRACT

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ABSTRACT : *The critical objective of construction industries nowadays is to complete a project within a stipulated time and cost through process standardization, minimization of waste, and organizational potential and efficient use of resources by using recent techniques such as Lean six sigma. Lean six sigma in construction was found to be rigorously studied most of the literature has focused on the application of Lean six sigma applied in the variety of fields hence the main aim of this paper is to conduct rigorous review and to identify the potential aspects of their application in Indian construction management. Most of the construction companies face poor client satisfaction due to non completion of the work as per the required standard and specification. For the industry to increase its profit margin and remain competitive in the market, completion of a project as stipulated is crucial. In this paper efforts are made to establish complete analysis of 51 papers with data base search from major publishers including Science Direct, Emerald and Google Scholars. This paper reviews the published literature related to six sigma or lean six sigma in construction from start to date. The statistical calculation consist of the response from the year 2003 up to 2012 they include number of publications in the respective years and after a pilot study a sample of 51 Papers were considered and statics is done .Six sigma refers to the minimization of variation through proper work flow maintenance and it leads to performance improvement of contractors in terms of cost and quality. It ensures that construction processes become leaner and cost competitive. The paper includes the results from different perspectives such as implementation of Lean six sigma, Focus Area, Focus Country and Year Wise Publications. The review of literature Related to Abstract found that six sigma or Lean Six Sigma in construction industry is mostly implemented in quality and process improvement area. Research on LSS is on elementary stage. Lean Six sigma framework in construction organizations is needed. This paper discusses different articles that have been published in this field and present a literature review Related to Abstract.*

Key Words: *Lean Six Sigma And Lean , Six Sigma.*

Introduction:

The Greek alphabet Sigma (σ) has become the statistical symbol and metric of process variation. The sigma scale of measurement is perfectly correlated to such characteristics as defects-per-unit, parts-per-million defectives, and the probability of a failure. Six is the number of sigma measured in a process, which has a target variation of only 3.4 per million as defects under the assumption that the process average could diverge over the long term by as much as 1.5 standard deviations. Six Sigma can be defined in several ways. Tomkins (1997) defines Six Sigma to be “a program aimed at the near-elimination of defects from every product, process and transaction.” Harry (1998) defines Six Sigma to be “a strategic initiative to boost profitability, increase market share and improve customer satisfaction through statistical tools that can lead to breakthrough quantum gains in quality.” Six Sigma was launched by Motorola in 1987. As a result of a series of changes in the quality area starting in the late 1970s, with ambitious ten-fold improvement drives. After some internal pilot implementations, Galvin, in 1987, formulated the goal of “achieving Six-Sigma

capability by 1992” in a memo to all Motorola employees (Bhote, 1989). The reduction in process variations were on-track and cost savings totaled US\$13 billion with labor productivity achieved 204% increase for over period 1987–1997 (Losianowycz, 1999) to companies such as IBM, DEC, and Texas Instruments launching Six Sigma initiatives in early 1990s. However, it was only part 1995 when GE and Allied Signal launched Six Sigma that a rapid dissemination took place in non-electronic industries all over the world (Hendricks and Kelbaugh, 1998). In early 1997, the Samsung and LG Groups in Korea began to introduce Six Sigma, Samsung SDI, reported a cost savings through Six Sigma projects totaling US\$150 million (Samsung SDI, 2000a). It is statistical measurement of quality level. It is a new management strategy to create quality innovation and total customer satisfaction. As a means of doing things right the first time and work smarter by using data information. (Six Sigma for Quality and Productivity Promotion ©APO 2003, ISBN: 92-833-1722-X by Sung H. Park)

METHODOLOGY

Approach was adopted to explore the published literature regarding six sigma or lean six sigma in construction. It involved searches from the well known research databases like, Emerald, Google scholar and Science direct. The literature search is limited to the English language only. I found total 51 articles highly related with six sigma in construction. The criteria of selection of the papers includes that the publication must have LSS, Lean and six sigma or six sigma in construction combined applied either as a case study or described as theory. The search years included from 2003 to December 2011. The search results were sorted out as area focused, year wise publications and country wise research on lean six sigma. The data collected, analyzed and the results are presented in graphical.

Review of Literature Related to Abstract:

The philosophy of six sigma has come under the focus of researchers because it increases the organizational efficiency and helps in high-quality construction with minimum efforts. A number of authors have discussed the concept of six sigma in the construction from 2000 to 2012.

According to Muharrem Firat Yilmaz (Six Sigma within construction context as a quality initiative, performance indicator/improver, management strategy, 2012), Six Sigma was developed in 1980s in the manufacturing industry and became popular as a process improvement method. However, the adoption of this concept is new to the construction industry and the aim of this study is to evaluate Six Sigma as a process improvement method in the construction industry context. This paper comprises of literature review and discussing process improvement methods used in the construction industry and analysis of features and principles of six sigma and there in to review of a project manager, a field and a cost engineers on the same. The interview on Six Sigma is based on quality, performance and management aspects. This study defends and removes any doubt about the positive effects of Six Sigma on construction projects. Particularly, Six Sigma can provide a broader quality concept, detailed performance measurement, and coordination in repetitive process is and performance improvement. It has produced quality improvements directly/indirectly with positive increase in production efficiency.

Hongbo Wang (2008, IEEE, PP 1 to 4) explains that Six Sigma is an approach that improves quality by analyzing data with statistical inputs and essential to have a review on the Six Sigma approach. He details the methodology, implementation and future scope of research. Which summaries four sub-categories of Six Sigma as basic concepts: DMAIC, DFSS and

deployment. Also, some sectors that benefit from the implementation of Six Sigma are listed, and the key factors influencing the successful implementation of Six Sigma in project are identified.

Silvio Burrattino Melhado (Design for lean construction, Proceeding IGLC 98) says that an initial draft of guidelines has to be conceptualized to fit design methods based on lean construction principles. It results in innovative design procedures that illustrates the application of "lean thinking design" for production efficiency improvement in building construction companies. The main concepts related to lean construction are discussed under design and production points of view as well as the optimal managerial relations among building design procedures and production activities. An experience of using innovative design methods is described as a practical reference. The proposed design methodology results in changes to the traditional design team arrangement and also to the design development and co-ordination. The difficulties on the implementation of the proposal in the building construction industry are briefly examined.

Luis F. Alarcón et. al (Revista Ingeniería de Construcción Vol. 23 No1, April d 2008) describes that over the last 10 years an increasing number of companies have implemented lean construction practices in an attempt to improve performance in construction projects. However, there is still a need to provide more extensive analysis of the empirical evidence available to assess the impact of the implementation of lean construction. The authors have researched the implementation of the Last Planner System and other Lean Construction techniques in over a hundred construction projects in the last five years. They have also developed strategies and support tools for implementation. He analyzes some of the main impacts observed in the studied projects, and some of the lessons learned from implementations. The paper discusses difficulties and barriers in implementation, productivity improvements, variability reduction and effectiveness of implementation strategies. The paper also provides recommendations for future implementation and research.

Glenn Ballard et. Al (Presented at the 2nd Annual Conference on Lean Construction at Catolica Universidad de Chile Santiago, Chile September 1994) explains that Lean construction has at least two foci that distinguishes it from traditional construction management. One focus is on waste and the reduction of waste. Breaking away from the conversion process model, and reconceiving production processes in terms of Koskela's flow process model (1) The time quantities and money wasted when materials and information are defective or idle. Instead of simply improving the efficiency of conversion processes, the

task is extended to the management of flows between conversions. Consequently, in addition to its focus on waste, lean construction also focuses on managing flows, and to do so, puts management systems and processes into the spotlight along with production processes. Flow management is a much more difficult task on complex, fast track projects such as refineries, chemical plants, food processing plants, paper mills, etc. (2) He has explain supply chains, many competitors, typically are under the time pressure to hit the market for product launches, and are subject to multiple, extensive process design changes motivated by the opportunity to gain more profit money than is lost through disruption of construction. In this environment, traditional approaches to construction management fail miserably. The conversion process model conceals everything that needs to be revealed; particularly the design of systems and processes to manage work and work flow.

Maryam Dabbaghi Tehrani (University of Boaras, Feb.2010) describes the importance of quality improvement and excellent performance in a highly competitive world market that lead many organizations, their top managers, project managers, and engineers to implement the new philosophies such as pull scheduling and lean principle at their organizations. He describes Six Sigma principle and framework as a quality improvement strategy through the successful business. The background of the Six Sigma in industry is described and statistical theory behind is illustrated. Although the Six Sigma concept is presented in terms of principles, methodologies and framework, the main focus of this report is on adopting the Six Sigma approach in construction projects which is still new concept in construction industry.

Kimberly Eve Furphy (Arizona State University, Dec.2010) says that with increasing interest in sustainability and green building, organizations implement programmes such as Leadership in Energy and Environmental Design for Existing Buildings: Operations and Maintenance (LEED-EB) in order to focus corporate sustainability goals on the operations of a facility and the practices of the building occupants. In addition to various environmental benefits, green building programmes help companies become more efficient. The problem is that organizations are not always successful in their pursuits to achieve sustainability goals. This thesis addresses how the Six Sigma methodologies used by many to implement change in their organizations could be applied to the LEED-EB program to help companies achieve sustainability results. A qualitative analysis of the Six Sigma methodologies was performed to determine if and how a LEED-EB program might utilize such methods.

Bulent Algan Tezel (A statistical approach to lean construction implementations of construction companies in Turkey, Aug. 2007). This thesis analyzes the practices of the construction companies in Turkey from the lean construction perspective. Prior to the analysis in question, requisite information about change in the construction industry, lean thinking and lean construction is presented. A questionnaire, based on a lean construction model, is used to survey the practices and gather the data for the analysis. According to these analyses, the lean construction characteristics of the construction companies is discussed and the recommendations for improving the lean conformance of the construction companies is presented.

O. Salem et al (Journal of Management In Engineering © ASCE / October 2006) compares the techniques developed for lean construction with those developed for lean manufacturing. Lean manufacturing and lean construction techniques share many common elements despite the obvious differences in their assembly environments and processes. Manufacturing plants and construction sites are different in many ways that could explain why lean production theories and practices do not fully fit the construction industry. Though many lean construction tools and elements are still in an embryonic state, lean construction techniques are gaining popularity because they can affect the bottom line of projects. Additionally, this paper presents a study of a construction project in which specific lean construction elements were tested. Based on the findings of the study, a new "lean assessment tool" is proposed to quantify the results of lean implementations. The assessment tool evaluates six lean construction elements: last planner, increased visualization, huddle meetings, first-run studies, five S's, and fail safe for quality. This paper provides a simple and comprehensive approach that is transferable to any construction project.

Seung Heon Han (Journal of Management In Engineering © ASCE / October 2006). In the pursuit of productivity improvement, it is important to ensure the quality of work processes to enhance the overall reliability and stability of construction operations. There have been a number of construction productivity improvement principles such as lean production, just-in-time (JIT), rapid machinery changeovers, pull scheduling, last planner, etc. Thomas et al. 2003. Despite the successful applications, however, most of the results fell short of our expectations of a quantitative and practical method or metrics for assessing the defect rates of construction operations. The defect rate in construction processes is largely caused by unreliable workflow when sources of process variability are involved Tommelein 2000; Hopp and Spearman 2000; Howell et al. 2001; Thomas et al. 2002. In

order to estimate the defect rates involved in construction operations in a more quantitative and organized way, this research applies the six sigma principle. This study focuses on the development of the general methodology to apply the six sigma principles on construction operations rather than construction materials in terms of the barometers to measure, evaluate, and improve construction performance. This study also pursues process effectiveness differently from an existing efficiency-oriented approach that is simply an average production divided by time or resources while disregarding the variation of the production rate and resource usage. We investigate the concept that the reduction of variability in view of process effectiveness i.e., stable resource usage, reduced variation in cycle time, etc. will improve project performance through such outputs as the drop of cycle time, enlargement of productivity, optimization of buffer size, etc. Typically, project performance is measured after a project is completed so it might be difficult to improve process effectiveness without a definite goal for performance improvement. In this paper, this “performance indicator” is called six sigma. Project managers can use it to establish an explicit goal as well as to evaluate the level of project performance nearly perfectly. Among a variety of types of construction projects, this research is focused on a simple and repetitive construction process as an exploratory application. The proposed principle is also intended to be applicable to construction operations with more complex processes.

Apollo Tutesigensi and Valeri Pleim (White Rose Research Online) Many organizations have implemented 6 σ and achieved significant levels of success. Successful implementation of 6 σ leads to outcomes that would be welcome in the construction industry, given its reputation of suboptimal performance. The construction industry relies heavily on small and medium enterprises (SMEs). Any improvement in construction SMEs would lead to improvements in the construction industry as a whole. Against this background, a survey was undertaken to establish whether construction SMEs used 6 σ and to identify factors affecting the adoption of this business strategy. It was found that none of the SMEs in the sample used 6 σ . The reasons given for not employing 6 σ , in descending order of importance, were lack of knowledge about 6 σ programme; lack of resources (human, time, money); 6 σ programme not required by customers; other sufficient quality system in use; 6 σ provides no perceived benefits; and end users not prepared to pay for 6 σ programme. These reasons can be challenged when a critical analysis of innovation in the external environment within which construction SMEs operate, trends in the mode of delivery of construction industry products, trends in performance measurement in the construction

industry and the flexibility of 6 σ as a quantitative approach to managing quality.

C. William Hames & Ron Rabine explain that, the construction industry has struggled to fully embrace the philosophy of defect prevention rather than detection as a quality objective. This paper explores quality principles and methodologies employed in the manufacturing industry over the past twenty years that have resulted in measurable performance improvements yet are not adopted by the construction industry. The focus of the paper is why the construction industry struggles to use integrated process control systems to comply with established standards and the effect of our culture on quality improvement deployment and obtainment.

RESULTS

Out of total 51 Lean Six Sigma in construction relevant found research publications there are 05(10%) papers are case study based while 08 (16) % papers are theory based. Figure 1 shows the focus area of implementation of LSS mainly has been quality & Process improvement. The organization adopted LSS either to get better their processes or modify them to increase efficiency and productivity. Literature Review had discussed process improvement methods used in construction industry and analyzed the basic features and principles of Six Sigma. Interviews were conducted about the basic principles of Six Sigma and Quality Concept. Interviewers are a Project Manager, Field and Cost Engineer. The approach of the interview to Six Sigma is based on quality, performance and management aspects.

This paper reviews some related literatures to describe methodology, implementation and future researches. Papers summaries four issues within the sub-category of the initial Six Sigma concepts: basic concept, DMAIC, DFSS and deployment. Then, some sectors that benefit from the implementation of Six Sigma are listed out, and the key factors influencing the successful Six Sigma project implementation are identified.

This paper proposes an initial draft of guidelines to fit design methods based on lean construction principles. It results into innovative design procedures that can illustrate the application of “lean thinking design” for production efficiency improvement in building construction companies. The main concepts related to lean construction are discussed under design and production points of view as well as the optimal managerial relations among building design procedures and production activities. An experience of using innovative design methods is described as a practical reference.

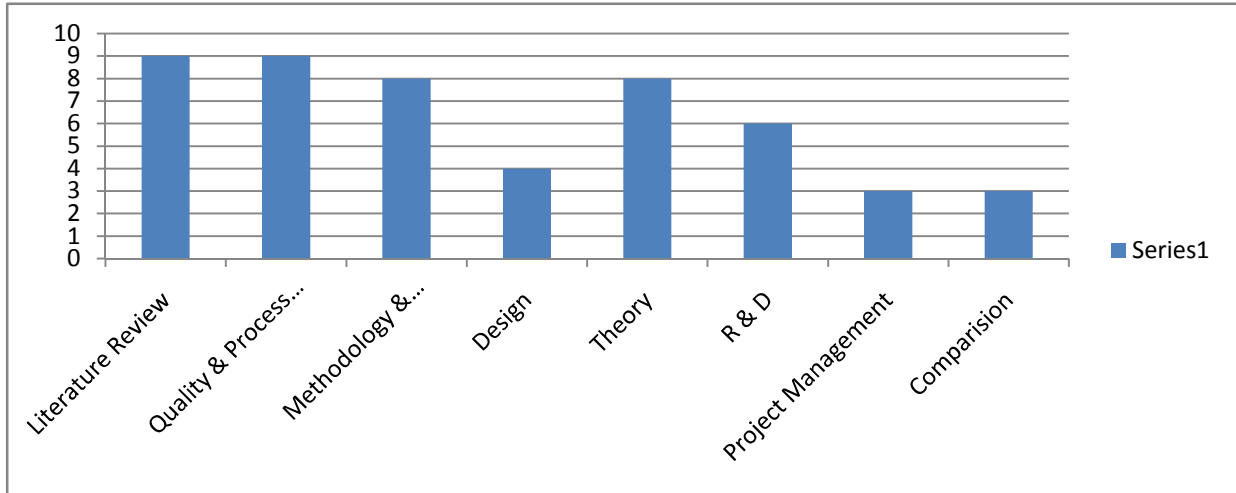


Fig.1. Publication and Focus Area

Figure 2 shows that LSS or six sigma researches is indifference to developed and developing countries. USA is leader in LSS related research following is the China and afterwards UK and Gulf country stand

on same position. Remaining category in the fig. includes different other countries with comparatively less research on Lean Six Sigma.

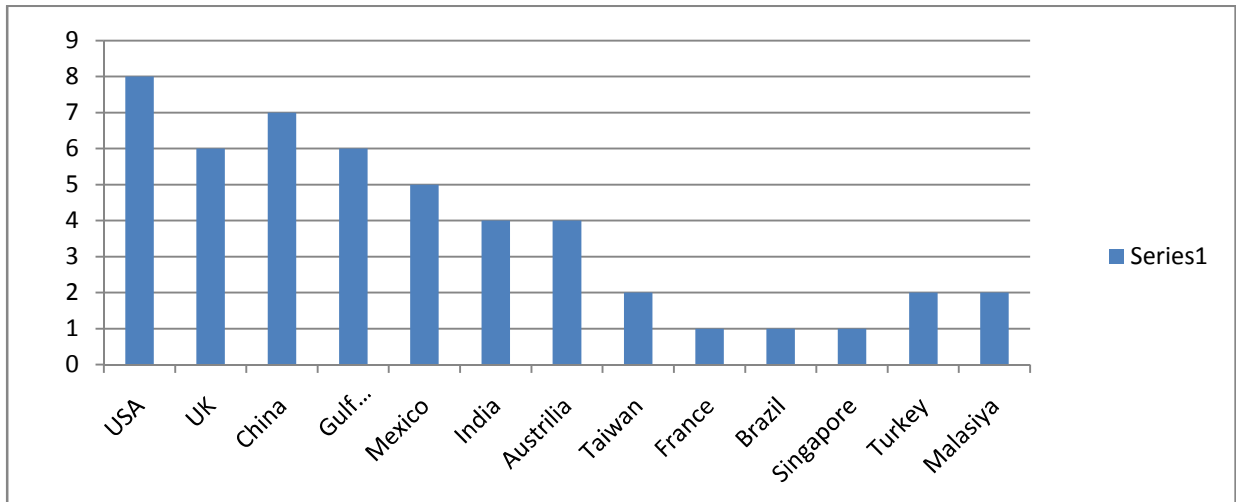


Fig.2. Publication and Focus Country

Figure 3 shows that the research and implementation on Lean Six Sigma in publication started at 2003. Afterward research is continuously increasing as organization know better about the successful

stories of world top performing construction organization using Lean six sigma. Much research has been done in 2010 nearly 09 publications.

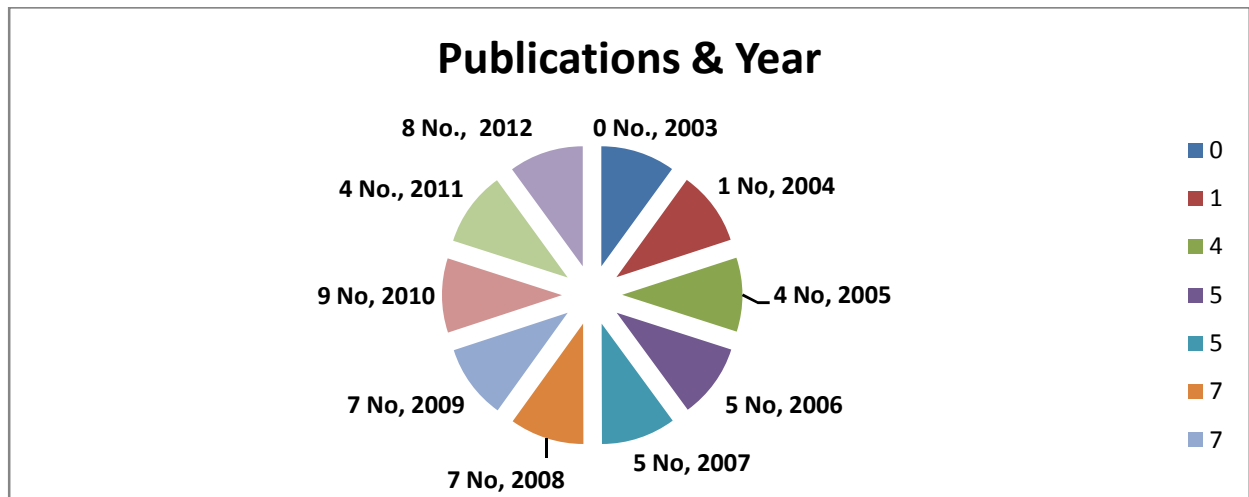


Fig.3. Publication and Year

LSS or Six Sigma has been proved quite effective in construction organization. But there is need to explore more this sector for theory evolution regarding the implementation of LSS in construction organization.

Conclusion:

From the paper, it recognize that at this point vast literature obtainable on six sigma philosophy, which gives a wide idea of precedent practices and researches carried across the globe. Six sigma philosophy is widely accepted by manufacturing industries and it also possible to implemented in construction industry with little fragment modify more research work is required in this field, so great scope of research is accessible for new researchers in this field. Past case study disclose that it required team efforts involving top management and every worker in the organization to fully employ the philosophy. However, consciousness among consultant, engineers and employees regarding six sigma in construction should be produced. From various literatures conclusion author feel that, uses of six sigma in construction industry under different situation plays significant role. In current years there has been a lot of attention in the application of Six Sigma principles. Several papers have been presented on this subject substantiating the importance of adopting Six Sigma to improve process performance. This research is carried out to identify the latest trends, focus area in construction, year wise publications and country wise publications of Six Sigma in construction with other concepts by carrying out a systematic, thematic literature review.

In current years there has been a lot of attention in the application of Six Sigma principles. Several papers have been presented on this subject substantiating the importance of adopting Six Sigma

to improve process performance. This research is carried out to identify the latest trends, focus area in construction, year wise publications and country wise publications of Six Sigma in construction with other concepts by carrying out a systematic, thematic literature review.

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