# SIX SIGMA APPROACH IN MATERIAL MANAGEMENT

[1] Miss. Priyanka K Gabhane, [2]Mr. Satish S. Deshmukh,[3]Mr. Shrikant R. Kate,
[1] PG Scholar, [2] Associate Professor, [3]Assistant Professor,
[1] Department of Civil Engineering,
[1] Trinity Academy Of Engineering (TAE), Savitribai Phule Pune University, Pune, India

***Abstract :*** The basic purpose of this project is to explore and study the implementation of six sigma principles in order to identify and minimize the defects and wastages that occur on a construction site.In recent years, construction companies have begun using Six Sigma methodology to reduce errors, excessive cycle times, inefficient processes and cost overruns. In construction we can say that, anything that does not match the requirements comes under the term 'defect'. Late delivery and excessive wastage on site also be labeled under defects. In order to identify the defects on a project; a complete structure can be studied and tested regarding different perspectives. Therefore, in this paper an attempt is made to follow the DMAIC approach to identify the area of wastages of materials and rectify them. The primary objective being deriving reasons that lead to materials wastage on a residential site. Also, some fundamentals are included such as basic definitions and philosophy, efficient communication, team work, training and management, involvement and commitment. Moreover, besides defect reductions some other important results were observed in the implementation process, such as culture change, trained employees and better human resources and better project management skills. In conclusion, there were changes suggested for the better in the organizations where Six Sigma was implemented.

***Index Terms*** **- Construction industry, DMAIC, Material wastages, Material planning, Six Sigma, Project Management.**

## I. INTRODUCTION

Minimizing waste and optimizing the profitability can be achieved by reducing the cost of the material with proper planning, scheduling, purchase, procurement, inspecting, handling and storage. The term 'wastage' refers to the variance between estimated and actual consumption of a single item and total consumption of all other inputs on the site. The fundamental principle of six sigma is to improve customer satisfaction by reducing defects; ultimately it aims at a virtually defect-free process. The wastage created on site if re-used and re-cycled for other processes can turn out to be beneficial. Six sigma is easier to apply than many other quality management programs because it provides information about the change needed.

## II. BASIC STATISTICS OF SIX SIGMA

At early 1980s, Motorola Corp was the initiator of the Six Sigma concept and led the organization successfully through the implementation of the Six Sigma principles. However, till mid 1990s when the organizations such as General Electric and Black & Decker adopted the Six Sigma principles for quality improvement, the concept became popular. Since then, many organizations have been impressed by Six Sigma framework towards achieving excellence in their performance. The Greek alphabet Sigma has become the statistical symbol and metric of process variation. The sigma scale of measurement is perfectly correlated to characteristics such 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. The Six Sigma principle can be represented on a normally distributed product quality distribution curve. When the mean is located at the center of the normal distribution curve, the lower and upper limits are six times the standard deviation (sigma) from the center line.

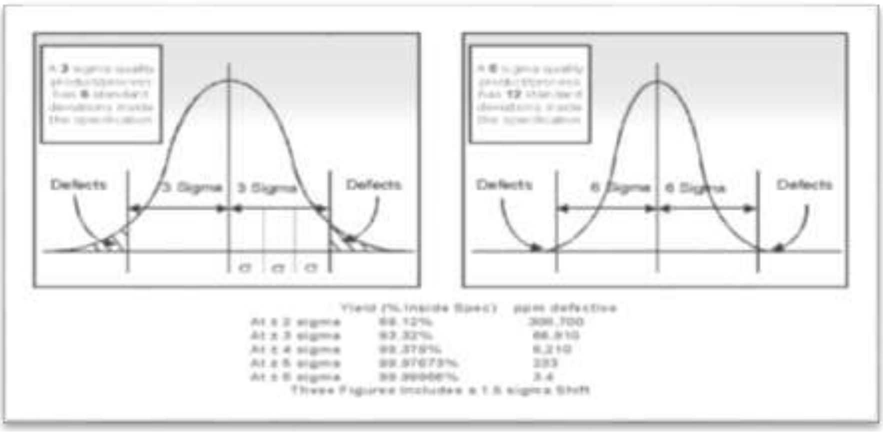
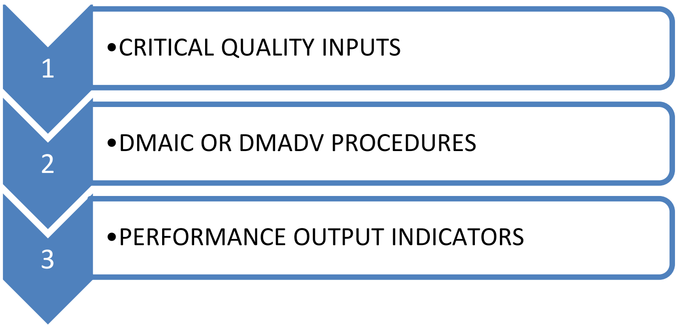



Figure 1- Six Sigma Distribution Curve

## III. THE CONCEPTUAL STRUCTURE OF SIX-SIGMA BASED MANAGEMENT

The six sigma concept can be applied to the construction process within the basic framework of critical quality inputs, DMAIC procedures and output measures as shown in chart below,




**DMAIC Process**

DMAIC approach is more suitable when the current design of the products, services and processes are correct and satisfactory regarding to the requirements of customers and business. This methodology offers structured framework in following steps to establish systematic continuous improvement. The Six Sigma lifecycle is based on Deming's PDCA model (Plan, Do, Check, Act) and consists of five stages:

- Define
- Measure
- Analyze
- Improve
- Control

**Define-**This stage is where the firm has to reach an agreement with the Stakeholders in regards to the goal, scope, financial and performance targets of the project. It is important to do this stage correctly, as it sets the foundations for the rest of the project. It involves project start-up, customer requirement gathering and communications.

**Measure-**Identify and collect the appropriate data which are relevant to the defects and the processes need improvement. Measure the processes performance and establish the measurement system based on Six Sigma techniques and tools. Activities include process mapping and performance data collection.

**Analyze-** The knowledge gathered about the process is used to determine the key variables and relate them to the improvement goals. This is the stage where statistical analysis tools are employed to identify significant causes of variation. Significant causes of waste will also be determined.

**Improve-** The solution or solutions are determined in this stage. Ideas based on the analysis stage are generated, selected and verified. They are then implemented across the site, using change management techniques to increase their chance of sticking.

**Control-** It is where the change becomes part of the organization's normal behavior through monitoring and controlling. After a period of time, the process will be embedded and the true improvement in performance will be seen. It is important to capture this and ensure that the objectives have truly been met.

## IV. SIX SIGMA IN CONSTRUCTION

In this paper a case study is made on organization, to identify the waste and its minimization by six-sigma methods. In this study work the basic aim was how to eliminate waste in construction project site. Table 1showsthedetails of construction companies, their experience, and type of projects handled etc .based on their previous experience they have identified the likely percentage of wastage for various materials occurring on their previous project. This percentage limit is given in Table 2 and Table 3 represents Planned Percentage of Wastage, Actual Percentage Wastages & Total Percentage Wastages which is based on quality of material required as per approved design and quantity of material as per bill paid to material supplier the percentage wastage calculated as per eliminated waste, which sets for the Define Phase. Table 4 shows the measure phase along with the Graph 1.The analysis phase contains the cause and effect diagram resulting into wastages. Affinity Diagram is an outcome of the various brainstorming sessions and different ideas are gathered under a single head, suggesting improvement phase. Finally, the control phase in which the different control measures were carried out in their respective firms and monitored periodically.

**Define Phase**

In this phase of the case study the problem statement can be defined, the various firms based on their previous work experience have forecasted the amount of material wastage.

**Table 1: Details of Case Study**

| Particulars Of the Firm | Work Experience | Current Projects | Specialization | Means Of Waste Identification | Perspective towards Waste |
|---|---|---|---|---|---|
| A Builders and Contractors | 12-13 yrs. | Housing, Residential | Government Schemes, Flat/Bungalows | Visual | Any wastage, whether small or large contributes to national waste. Therefore should be reduced |
| B Builders and Contractors | 7 yrs. | Flat System , Commercial Complexes | Flat/Bungalows | Visual | Some wastage on site is inevitable. However all efforts should be made to reduce it. |
| C Builders and Contractors | 5-7 yrs. | Housing, Residential | Government Schemes, Flat/Bungalows | Visual | Initially waste control needs awareness and cost for proper disposal. Government rules should be applied. |

**Table 2: Planned Material Wastage**

| Materials | Company A | Company B | Company C |
|---|---|---|---|
| Cement | 4% | 2% | 4% |
| Sand | 5% | 4% | 5% |
| Coarse Aggregate (10mm) | 5% | 4% | 5% |
| Coarse Aggregate (20mm) | 5% | 4% | 5% |
| Steel Reinforcement | 3% | 2% | 2% |
| Bricks | 5% | 10% | 5% |

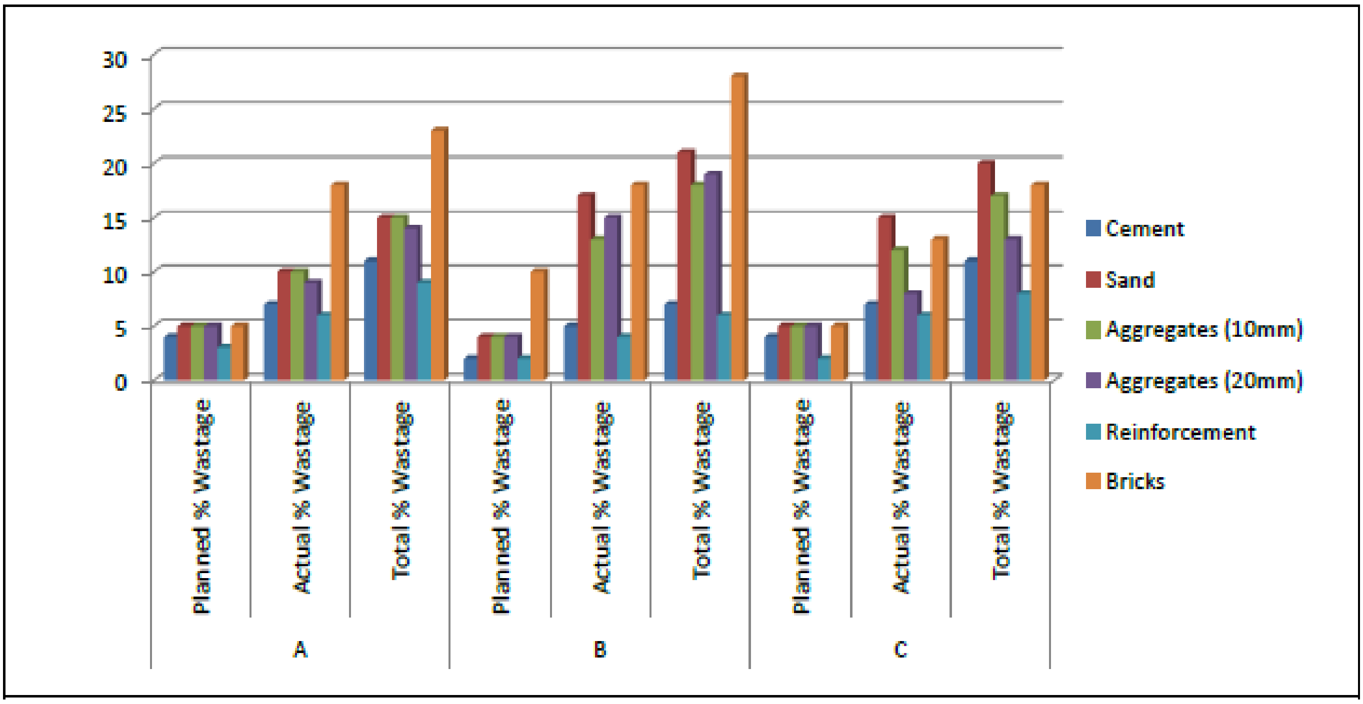
**Measure Phase**

In this phase the actual wastage of material on sites is measured and a graph is plotted between the actual, planned and the total material wastages that took place on the site.

**Table 3. Comparison of Actual % Wastage and Planned % Wastage**

| Sr. No. | Materials | A | | | B | | | C | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Planned % Wastage | Actual % Wastage | Total % Wastage | Planned % Wastage | Actual % Wastage | Total % Wastage | Planned % Wastage | Actual % Wastage | Total % Wastage |
| 1 | Cement | 4 | 7 | 11 | 2 | 5 | 7 | 4 | 7 | 11 |
| 2 | Sand | 5 | 10 | 15 | 4 | 17 | 21 | 5 | 15 | 20 |
| 3 | Aggregates (10mm) | 5 | 10 | 15 | 4 | 13 | 18 | 5 | 12 | 17 |
| 4 | Aggregates (20mm) | 5 | 9 | 14 | 4 | 15 | 19 | 5 | 8 | 13 |
| 5 | Reinforcement | 3 | 6 | 9 | 2 | 4 | 6 | 2 | 6 | 8 |
| 6 | Bricks | 5 | 18 | 23 | 10 | 18 | 28 | 5 | 13 | 18 |

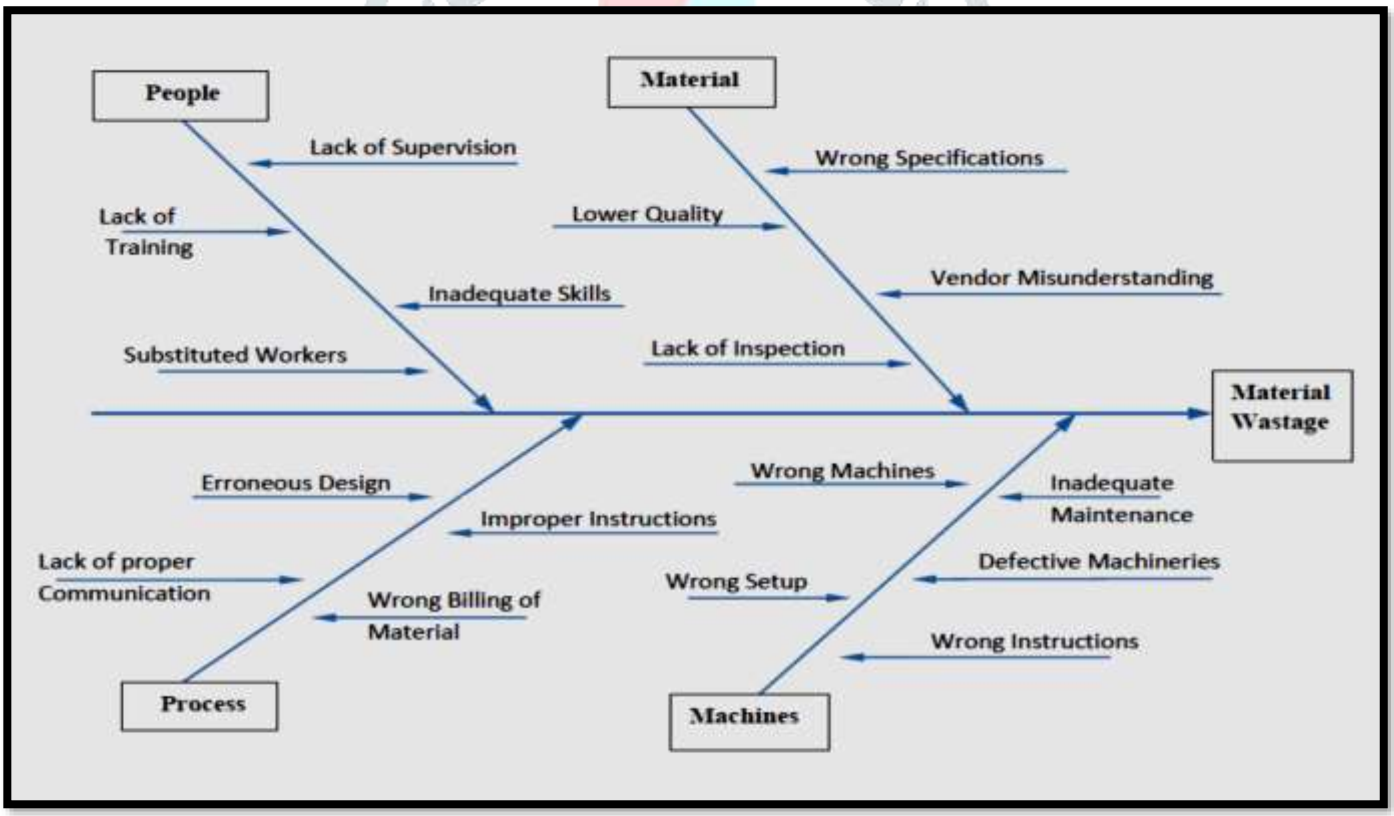
**Graph 1. Comparison of Planned, Actual and Total Wastage on sites**




## Analyses Phase

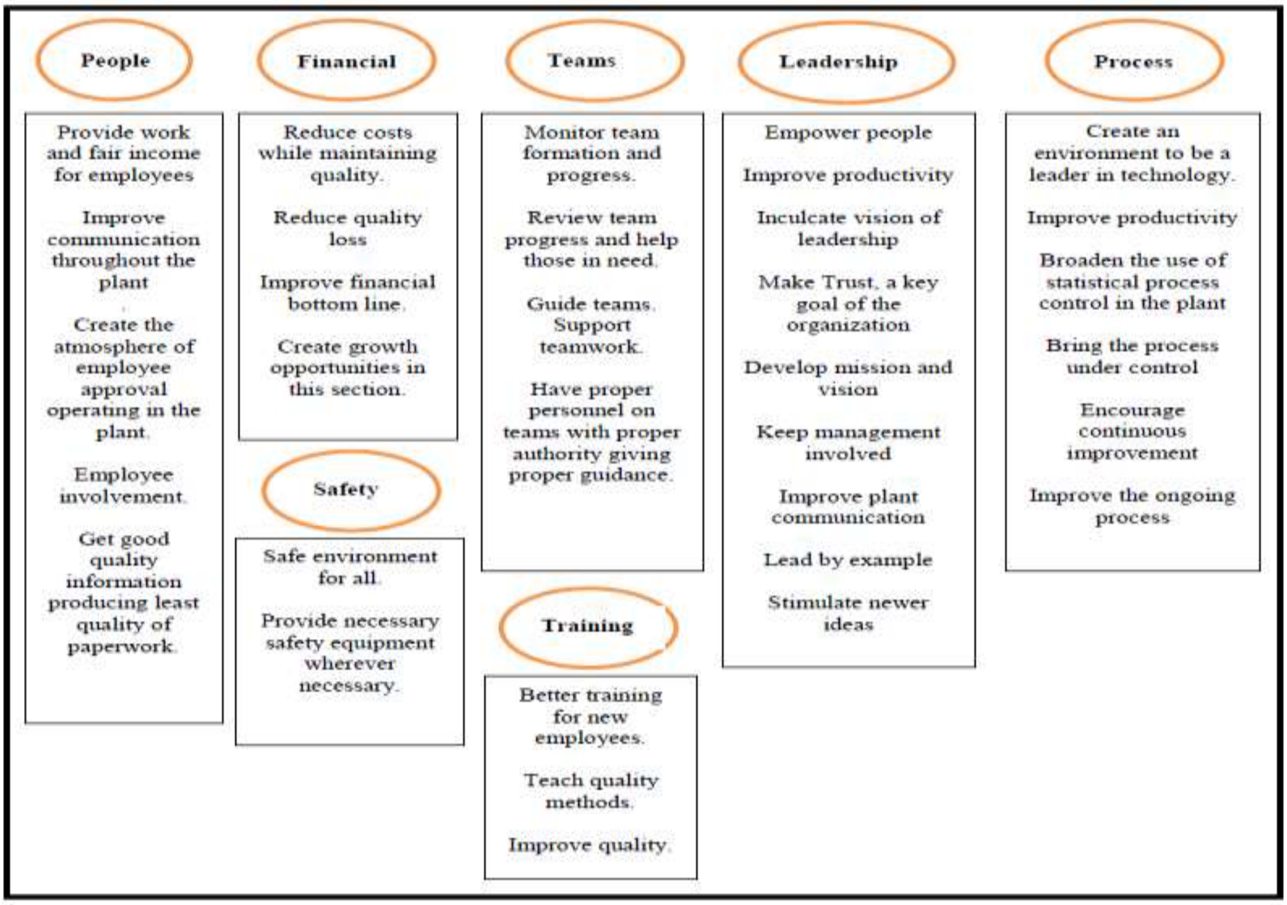
In this phase the potential causes of material wastage were plotted down and converted into a brief Fishbone diagram.

Cause and Effect Diagram




## Improve Phase

The set of ideas generated from brief discussions with the project managers were merged under specified heads, thereby making it easier to suggest improvements.




**Control Phase**

The objective of this phase will be; to continue measuring the performance of the process periodically and keep it under control. The goal of the project was to highlight the reasons that cause material wastages from their various sources, organize them and combine the information into one comprehensive report for analysis. To sustain the results, the team standardized, documented and distributed the control measures to be followed on site. Also, the ongoing performance was monitored which became a part of the formal performance evaluation process.

## V. CONCLUSION

It is thus clearly seen how various factors have high impact on the quality of the construction. These factors must be identified as early as possible so that the quality can be improved. The study also clearly shows that there is a notable difference between the actual percentage of materials wasted on site and the planned quantity of material for wastage. It can be concluded that nearly 20% of the materials having heavy contribution towards the cost of the project go wasted because of improper planning of activities which could have been reduced significantly by use of proper management systems. It can also be seen that wastage of material is reduced where skilled labours is available for mild steel. Thus, skilled labours can also contribute towards reducing wastages considerably.

## VI. ACKNOWLEDGMENT

I render my profound sense of gratitude to my guide Prof. S. S. Deshmukh Head of Department, Civil & Environmental Engineering Department for his inspiring and most keen guidance and suggestions. His experience in the subject has drawn up this report to an extent, which cannot be expressed by more words. I would like to express my sincere thanks to him for providing the help to complete the report. I also take opportunity to thank Mr. Bhaskar Pawar, PM @ Shree Ganesh Constructions, PM @ B.G.S. Pune and Mr. Pranit Rathee PM @ R.D.Contractors for helping me and providing me with all the data necessary for completion of the research work and also all the staff-members of the Civil Engineering Department for their valuable co-operation.

## VII. REFERENCES

**[1]** Applying Six Sigma Principles in Construction Industry for Quality Improvement; Sneha P. Sawant and Smita V. Pataskar; Proc. of the Intl. Conf. on Advances In Engineering And Technology - ICAET-2014 ISBN: 978-1-63248-028-6.

**[2]** The six sigma project management Strategy; Samman, R A and Graham; I (2007) In: Boyd, D (Ed) Procs 23rd Annual ARCOM Conference, 3-5 September 2007, Belfast, UK, Association of Researchers in Construction Management, 587-596.

**[3]** Performance Improvement in Construction Project based on Six Sigma Principles; Maryam DabbaghiTehrani; Quality and Environmental Management, 60 ECTS creditsNo. 1/2010.

**[4]** Six sigma within construction context as a quality initiative, performance indicator/improver management stratergy; MuharremFiratYilmaz ; Department Of Real Eastates And Construction Management ;Master Theisis Number 176.

**[5]** Six Sigma-Based Approach to Improve Performance in Construction Operations; SeungHeon Han, M.Asce;Myung Jin Chae, Ph.D., P.E.; Keon Soon Im, P.E.; And Ho Dong Ryu; Journal Of Management In Engineering © Asce / January 2008 / 21.

**[6]** Six-Sigma In Lean Construction Systems: Opportunities And Challenges, Tariq S. Abdelhamid; Assistant Professor, 207 Farrall Hall ; Construction Management Program, Michigan State University,East Lansing, MI 48824-1323.

**[7]** Application of Six-Sigma in finance: a case study ;A. Ansari ,Diane Lockwood, Emil Thies, BatoulModarress ,Jessie Nino; Journal of Case Research in Business and Economics.

**[8]** Successful Projects from the Application of Six Sigma Methodology ;Jaime Sanchez and AdanValles-Chavez; Six Sigma Projects and Personal Experiences.

**[9]** Implementing Lean Six Sigma: A Case Study In Concrete Panel Production; Celep Oguz, Yong-Woo Kim , John Hutchison, and Seungheon Han; Proceedings for the 20th Annual Conference of the International Group for Lean Construction.

**[10]**Attributes Of Materials Management Systems;Lansford C. Bell1 and George Stukhart/ Members, ASCE; Journal of Construction Engineering and Management, Vol. 112, No. 1, March, 1986. ©ASCE, ISSN 0733-9364/86/0001-0014/$01.00. Paper No. 20411.

**[11]** Fundamental Principles of Site Material Management; H. Randolph Thomas; David R. Riley; and John I. Messner;DOI: 10.1061/~ASCE!0733-9364~2005!131:7~808; Journal Of Construction Engineering And Management © Asce / July 2005

**[12]** Quality Management Programs in the Construction Industry: Best Value Compared with Other Methodologies; Kenneth T. Sullivan, Ph.D, A.M.ASCE;DOI: 10.1061/(ASCE)ME.1943-5479.0000054.

**[13]** Materials Management Practices in the Construction Industry; Carlos H. Caldas, M.ASCE; Cindy L. Menches, M.ASCE; Pedro M. Reyes; Laure Navarro; and Daniel M. Vargas;DOI: 10.1061/(ASCE)SC.1943-5576.0000238. © 2014 American Society of Civil Engineers.

[**14]** A Construction Management Framework for Mass Customization in Traditional Construction ;María Dolores Andújar-Montoya , Virgilio Gilart-Iglesias , Andrés Montoyo and Diego Marcos-Jorquera;Sustainability 2015, 7, 5182-5210.