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IDENTIFICATION AND ELIMINATING WASTE IN CONSTRUCTION BY USING LEAN AND SIX SIGMA PRINCIPLES

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Abstract: The purpose of this paper is to explore the principle of lean and six sigma for identification and illumination of waste in construction organization. Efficient material management is essential in managing a productive and cost effective site. In this working career, the author has been observing inefficient labour productivity practices, resulting from poor site material management, and handling. In this paper, therefore an attempt has been made to rectify these activities and construction organization. Primary objective of the study is to derive the reasons contributing to the amount of material wasted on residential building sites, which needs to bring down substantially by devising suitable method. A case study follows that demonstrates, how lean thinking and six sigma principles, tools and techniques be applied to a public and semi government authorities.

Key words: Material Management, Project Management, Planning Storage Housekeeping

I. INTRODUCTION

Next to agriculture, construction is the second largest activity in India. During the last few years, enormous growth in infrastructure has been found, by wide range of diversity construction organization. Construction industry in India produces a large range of different waste as if bricks dismantle building portion, mild steel etc. A large and various types of waste are created at all the stages of construction right from site preparation, demolition of existing structures to final product. Minimizing the waste and optimizing the profitability is possible by reducing cost of material with proper planning, scheduling, purchasing, procurement, receiving, inspecting, handling, storing and warehousing. The term "wastage" refers to the variance, if any, between the estimated and actual consumption of an individual item and total factor consumption of all inputs in a construction project. Thus, wastage material in the use of an individual item can be reduced from the detailed engineering drawings and methodologies of work execution. It is important to note that Wastage refers to the amount of material wasted. Waste is anything, not needed. However, if somebody else can use it, rather as it is (called reuse), or by processing it (called recycling), then the waste created on site can turn out to be beneficial. Construction materials needed for a project work vary with the nature of the project. Determination of the type, quantity and specification of the construction materials needs a detailed study of the contract document, including the Bill of Quantity, drawings, specifications, pre-tender estimates and preliminary vendor inquiries. Material planning considers materials in the order of requirement at site. For example, in a building construction project, bulk materials and other items for site development, foundation work & superstructure frame, which are needed in the early stages of construction, are considered first. The others are taken up in the sequence of their requirements. Since 1940, lean production principles have been evolved and have been successfully implemented by Toyota Motor Company. Toyota strived to work towards the ideal of 100% value-added work with zero (or minimum) waste. Popularized by the 1990 book "The Machine That Changed the World", these lean principles is being increasingly employed in many other industrial sectors. The adoption and adaptation of lean production concepts in the construction industry has been an ongoing process, since 1992. An increasing number of construction academicians and professionals

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have been storming the ramparts of conventional construction management in an effort to deliver better value to owners and at the same time making greater profits. As a result, lean-based management tools have emerged as modern management practice in simple and complex construction project

II. LEAN PRODUCTION THEORY

Taiici Ohno, an engineer working for Toyota, developed the lean production theory as a method of eliminating waste. Ohno shifted the attention of researchers focus away from the effect of workers productivity on craft production towards a more encompassing production system as a whole. Ohno followed the work of Henry Ford's assembly line production to continue the development of flow-based production management. The underlying goal of lean production theory is the avoidance, elimination, or reduction of waste. Howell (1999) [1] defines waste as the difference in productivity when benchmarked against the performance criteria for a particular production system; failure to meet the unique requirements of a client is considered waste. Howell goes further in outlining this criterion by defining waste as time, space or material used in the performance of an activity that does not directly contribute value to the finished product. Using these broad definitions for waste, lean production theory attempts to move a production system towards perfection, or zero waste. A primary goal of lean production theory is to reduce or eliminate the share of flow activities in a project while increasing the efficiency of conversion activities. The following list outlines key principles of lean production theory (Koskela 1992) [2].

- Reduce the share of non value-adding activities
- Increase output value through a systematic consideration of customer requirements. (Improve response time to customer)
- Benchmark
- Reduce inventories (Reduce working capital requirements)
- Reduce cycle times. (Productivity improvement)
- Increase output flexibility.
- Increase process transparency.(Operational benefits)
- Focus on control of the overall process.(simplicity and visual control)
- Build on continually improving into the process.
- Balance flow improvement with conversion improvement.
- Simplify by minimizing the number of steps, parts or linkages.

Though lean production theory was developed for manufacturing, the similarities between craft manufacturing and the construction process makes the lean production theory ideal for application in the to construction sector also.

III. SIX SIGMA PRINCIPAL

Six Sigma is a business-driven, multi-faceted approach to process improvement, reduced costs, and increased profits. The primary goal of Six Sigma is to improve customer satisfaction, and thereby profitability, by reducing and eliminating defects. With a fundamental principle to improve customer satisfaction by reducing defects, its ultimate performance target is virtually defect-free processes and products. 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 integrate with existing models of software process implementation.

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

i) Everything is a process
ii) All processes have inherent variability

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iii) Data is used to understand the variability and drive process improvement decisions. 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."

We have implemented 5S for Construction in the following manner:

The 5S Process (Visual Work Place)

Lean construction visualizes the project as a flow of activities that must generate value to the customer (Dos Santos et al. 1998) [3]. The 5S process (sometimes referred to as the Visual Work Place) is about "a place for everything and everything in its place". It has five levels of housekeeping that can help in eliminating wasteful resources (Kobayashi 1995) [4]: Seiri (Sort) refers to separate needed tools / parts and remove unneeded materials (trash). Seiton (Straighten or set in order) is to arrange tools and materials for ease of use (stacks/bundles). Seiso (shine) means to clean up. Seiketsu (standardize) is to maintain the first 3Ss. Develop a standard 5S's work process with expectation for the system improvement. Shitsuke (sustain) refers to create the habit of conforming to the rules. This tool is similar to the 5S housekeeping system from lean manufacturing. The material layout is commonly used for acceleration of 5S implementation on the construction site. Spoore (2003) [5] indicates that 5S is an area-based system of control and improvement. The benefits from implementation of 5S include improved safety, productivity, quality, and set-up-times improvement, creation of space, reduced lead times, cycle times, increased machine uptime, improved morale, teamwork, and continuous improvement .

Designing 5S in Construction Process

Order and neatness are critical elements of the working environment. All material locations must be clearly marked. Only the necessary tools, fixtures, gauges, and other resources should be present at the workplace. No clutter or mess should be tolerated on the Lean line. Implementation of the Lean manufacturing methodologies in Construction Process supports the concepts of 5S. The elements of 5S and applied Lean methodologies are complementary.

Sifting (Seiri): Remove items not used for construction process on a regular basis.

A major component of the Lean manufacturing line implementation is the removal of items identified as unnecessary for the production of product. Such items include toolboxes, stools, personal items, unnecessary raw material. These items offer temptations to accumulate unwanted materials such as parts, tools, and other items not required for actual construction process.

The temptation to accumulate these types of items is part of the human condition. A comfort level comes with surrounding oneself with familiar objects. This is based on experiences like parts shortages, the unavailability of tools and fixtures. Operators like to create comfort with a "home away from home," made up of a collection of personal items. Often, these personal items are accumulated in a personal workplace. The establishment of personal workstations conflicts with the Lean manufacturing concepts of balance and flexibility.

Sorting (Seiton): Identify and arrange items that belong in the area - "a place for everything and everything in its place".

In addition to the physical location of workplace where work performed, there are always tools, fixtures and parts that must be so located that the operator can easily access them. Each of these required items should have an assigned location either at the workplace where the item is used for daily processes or adjacent to the point of usage. Suggestions include silhouette boards for tools and fixtures located within operator reach, painted squares on the floor, suspended air and electrical lines, and kanban racks and containers.

For all materials not used directly at the workstation, assigned locations are also important. Such materials include pallet jacks, forklifts, cleaning materials, trash receptacles, and any other portable material-handling fixtures. A "parking space" should be placed adjacent to the workplace where the item is used most frequently. The space should be painted, and material handlers must be disciplined to return the item to its parking space when not in use.

Sweeping (Seiso): Maintain order, sweep, and clean.

The reasons for maintaining a clean workplace are obvious. Operators should take pride in their workplace, and that pride is reflected in the product they build. Just as important, a clean workplace also provides an early warning system of problems. A cluttered workplace can hide problems such as rejected materials that indicate a defective quality process, spare parts that may indicate a faulty kanban system, or incomplete units that indicate an imbalance on the Lean line. A clean Lean line environment helps to make these potential problems conspicuous.

Time to perform these cleaning activities can be built into the Takt time calculation. A statement of minutes per shift makes up the numerator of the Takt time calculation. Time needed to perform cleanups at the beginning and end of each shift can be built into this calculation. Since resources for Lean manufacturing lines are based on the Takt time calculation, incorporating this activity into this calculation will provide the time necessary to do this work every day.

Standardize (Seiketsu): Practice management discipline.

Making the most of Lean manufacturing methodologies requires the minimization of individual interpretations when decisions must be made. Much effort has been invested in the design of the Lean line so that operators can maximize the time spent building product, with less time spent making decisions. Operators have been trained to respond to decisions using the Lean manufacturing methodologies. All operators should follow the same rules.

A key benefit for the Lean is the ability to perform MBWA, (Management By Walking Around) Walking through a Lean facility, it is very easy to see what is happening in manufacturing. The supervision required can often be decreased, because of the simplicity of the Lean line design.

Sustain (Shitsuke): It is management's responsibility to reinforce and demonstrate leadership.

Monitoring work conditions is the responsibility of the managers as they perform MBWA. When a member of the management team observes a violation of rules and chooses to say nothing about it, operators assume their behavior is acceptable. Operators are limited to individual interpretations at their workstations. Management must take ownership of solving problems on the Lean manufacturing lines. Managers have the advantage of seeing the bigger picture of the whole line.

Monitor Work Conditions: Use newly established housekeeping policies as a management tool to focus on details. Small details are the first to deteriorate on the line. Look for items that do not belong. Solve problems immediately.

Monitor Operator Flexibility: The ability of a Lean line to vary mix and adjust its volume on a daily basis, based on actual daily demand, is a key differentiator of your Lean line and batch manufacturing. This ability provides a competitive advantage to your company. Flexible employees are key elements of Lean manufacturing.

Monitor Overtime: The need for overtime should always be a temporary condition. It should only be used for unanticipated spikes in demand. If overtime is permanently required, it may be time to rebalance the Lean line with a new volume capacity.

Monitor Teamwork: Encourage team performance. Request ideas for continuous improvement. Allow people to have control over their own destiny. Be certain the teams focus on the performance of the line. Make certain teams have a simple and accessible kaizen or continuous improvement mechanism for improving the product or its processes.

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Monitor The Line's Performance: The proof of success is performance. Establish performance measurements for the line. Track them and publish them. Post performance measurements on the line to display the daily production target, along with progress of actual production.

Monitor In-Process Quality: Establish and continue emphasizing the value and importance of inspecting for quality criteria. The final objective is for all defects to be caught and fixed before they ever reach the quality assurance final inspection process, the last point of rejection, or the customer. Perform spot checks on the lines.

Monitor Training: Employee training is critical to ensuring a consistent and repeatable flow of product every day. The better-trained employees are, the more flexible they are. The more flexible employees are, the better the line will flow.

Operation of the Lean manufacturing methodologies requires a shift from the way work done in the past. Lean manufacturing methodologies are powerful, but they require support and maintenance. The benefits received from the implementation of the Lean manufacturing methodologies will be in direct proportion to management's commitment to making them work on the shop floor. When members of the management team do MBWA, they must be observe to avoid the violation of the Lean rules, make corrections immediately doing nothing to condone the behavior.

IV. CASE STUDY

A case study is made to find out the waste and its minimization by lean and six-sigma methods .This study has been made on four construction sites of Dhule district in Maharashtra. In this Study work a study was made on, how to eliminate waste in construction project site. Four (4) construction companies were selected based on complete avaibility of Technical data has been taken into consideration. Mr. Raju Marathe,(A), Mr. Salunkhe & Vijay Patil Partners of P.R. Associates, Dhule(B) and Mr. Patel & Patil from Souveniour Developers Pvt. Ltd; Dhule.(C) And Mr. Dhananjay Patil ,Dhule(D) The relevant data with the permission of these companies were collected from Mr. Dongare CA practitioner of these four companies. The more details of construction companies, their experience, type of projects handled etc are given in Table 1.Total minimization of wastage at construction site if not possible, is very difficult. Some wastage are always there due to some reason or other depending upon weather condition, unskilled labour, and tendency not to bother for waste as it is a loss to the owner and not to the work force. Based on their previous experience have identified the likely percentage waste of various material occurs in their previous project. This percentage limit for four companies are given in the Table 2.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. Planned Percentage of Wastage, Actual Percentage Wastages & Total Percentage Wastages is given in Table 3.

V. OBSERVATIONS AND COMMENTS

As can be seen from Table 3, that there is considerable waste than that of planned. Wastage in the construction industry in India is quite high and process improvement will help it to become cost effective and competitive. This study shows that there is always delay in material procurement from client. It also shows that there is lack of proper monitoring system on site to keep a check on the quantity of material when purchased and actual quantity received on site. Study depicts that in spite of inventory cost being calculated, there is scarcity of materials takes place. The study reveals that even though advantages of the codification and standardization are known it is not followed. None of the company has good storage system. It also states that in spite of being aware about the disadvantages of open store system and random access companies are following them. It is seen that allowable percentage of waste permitted in the companies is kept on higher side.

This study further reveals that the frequency of revision of planning fixed before the commencement of the project is observed in its implementation. It also implies that no efforts put in order to find out total amount of waste produced. It also reveals that when the waste exceeds the permissible percentage no efforts made to

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find errors in planning. The study states that in spite of being aware of the benefits of having particular level of housekeeping no efforts done to imply the same. It indicates that sequence of material to be used is not followed in proper manner and there is lack of appropriate storage facilities for materials on site.

These Wastages are hidden and as time lapses looses profit of the construction firm. Lean and six-sigma, which developed to improve productivity and to cut cost, can effectively be applied to construction organization by taking help from Lean leaders and professional. The construction organization needs positive thinking and top management (i.e. Owner) supposes to start on the Lean and Six Sigma implementation journey. They have to make fundamental changes in their strategic of production, quality improvement and adaptation of new technology. The high potential causes of material wastage on site comprises of improper planning, Poor management, improper quality control, lack of individual responsibility and overall negligence .The moderate potential causes range from Improper designs, improper specifications, Improper Labour and Supervision to Faulty systems and procedures and force majeure. The low potential causes include Lack of technological expertise, Unavailability of resources at required time, unhygienic working environment, Lack of standardization, poor distribution network and theft or Pilferage.

The study clearly states that there is a significant amount of difference between the percentage of material wasted and the allowable percentage on site. Activities studied during the course of work include consumption of cement, sand, 10mm aggregate, 20mm aggregate, formwork, reinforcement, and bricks. The study reveals that in case of Concreting, plaster, formwork, reinforcement and bricks, improper quality of material used is the basic reason behind its wastage. It can be seen from table 3that the percentage waste varies from 7% to 11% for cement, 15%to 24%for sand, 15%to 24% for 10 mm agreement, 13% to 19% for 20 mm aggregate, 5% to 14% for formwork, 6% to 14% for MS reinforcement, and 18% to 39 % for bricks.

It can be observed from Table 4 that on Cost of contribute in use of materials is 17% to 20% and material goes waste due to unplanned contribute activities which could have been reduced using proper management system. It can be further seen from table 3 that the waste of materials by properly having Labour have been reduced to considerable extent. In it is concludes how the cost of material waste can be reduced up the time of such the overall cost of material can be reduced by 15 to 20 percent by profit planning and wastage of Loss and Profit 77 percent.

Other observations made are;

Profit: As per earlier practices, the wastage of labour and material involved in any project have been found to be as 28 to 30 percent and 70 to72 percent respectively. However, from last 5 years, Labour cost has increased hereunder-making ratio of labour and material cost as 35-40, 65-60. However based on over experience for last few years, have taken this we have taken this ratio as 40-60. As such, a table has been prepared showing the cost of waste material all these projects for last four financial years. These are based on this financial report submitted to Income Tax department by their chartered practicener. This is shown in Table 4.

Cement: This study indicates that the recent trend of ordering cement by boozers and storing them in silos has significantly helped in reducing the problems related to cement bags storage and the waste amounts is 7% to 11%. When cement bags are obtained on the site each bag is not weighed, and if some of the bags are not having total weight that amount is not accounted for in the waste calculations.

Aggregates: The study discovers that for materials like sand, 10 mm, 20 mm, aggregates the frequent re-handballing of these material and lack of availability of space on the site leads to maximum amount of wastage. Also both being available easily and cost involve is less ,is always neglected and the wastage amount increases up to 15% to 24 % for sand 15% to 24%for 10mm aggregates13% to 19 % for 20mm aggregates.

Formwork: It is found that improper quality of formwork used and lacks of management of the same are the major hindrances and total waste generated is 5% to 14%. Latest formwork types are not used on some sites due to cost constraint given by the client.

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Reinforcement: The study states that various aspects including improper bar bending schedules, cutting of reinforcement, scrap management etc are the major factors causing wastage of reinforcement on site and the waste amounts up to 6% to 14% One of the reasons of reinforcement being wasted is that the bars obtained are longer than required. Other reasons contributing to waste in reinforcement are improper bending, small pieces not used and negligence. The MS steel is either Staten and sold as scrap at a very low rate.

Bricks: Improper quality of material used is the basic reason behind its wastage .Percentage wastage in case of bricks is 18%to 39%. In proper stacking leads to braking of bricks, .Basic reason is due to mishandling, shifting by labor. It has also been observed that waste occurred due to braking of bricks is used for their filling instated of murmur.

VI. CONCLUSIONS

It can be concluded from these findings that the prevalent conventional methods and thumb rules used in the companies contribute to material wastage on site. This study distinctly reveals that each aspect of working needs to integrate to reduce the amount of waste material on site.

Based on this study, response from company personals and observations made at site, some suggestions are made to cut down the quantum of waste generated on sites. These are:

1) Construction organization and its management

Projects with large work scope as well as different location require an organization that can carry out a systematic co-ordination of various construction aspects by assigning a team of trained personnel's for supervise the job and for maintaining quality, speed and economy. Achieving the task through disciplined work and efficient management groups as engineering, purchase, finance, account, administrative marketing scale legal electrical department should made separately with one in charge director.

2) Project management

Special training sessions are required to be arranged for workers at site in order to update the workers regarding the latest techniques. Plant and machineries should be regularity maintained to avoid any break down. Workers and contractors should be guide for correct methodology to execute a particular task. Regular checks should be made on planning to overcome error if any. Proper supervision should be made at site to improve the level of workmanship.

Proper planning should be carried at various levels, like micro and macro and be properly integrated. Reconciliation statements should be made at frequent intervals. Materials brought on the site are planned properly as per availability of space to store them. Proper designing be made requiring fewer revisions. Designing and calculations of material required be done with latest technological tools available to minimize the errors. Calculations of the quantity of material needed be made accurately. Planning should be done in such a manner that execution of work could be carried out at appropriate time in order to avoid any delays. Regular monitoring should be done to avoid amount of wastage occurring at site. In case material is not conforming as per the standard requirements, carry out appropriate tests to find its suitability for other activity.

3) Material Management

It is always a good practice to purchase materials from a single vendor considering all the parameters like quality, time and availability to avoid any delay and to have consistency in quality. Purchase of materials should be made as per requirement and availability of space at site. Proper integration of purchase schedule and construction schedule should be prepared in order to carry out work smoothly. Lead-time should be so decided that material did not deteriorate nor there is any scarcity.

Effective inventory control system should be established to keep a check on the amount of material consumed. It should be calculated accurately in order to avoid wastage. Software should be prepared in order to find out the total inventory of material required on site during execution as well as total cost it incurs.

Store and Housekeeping system should be implemented, preferably close to avoid any deterioration of materials. Proper record, in order to manage materials in a better manner should be maintained. A system of housekeeping should be devised to distribute the work in

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a proper manner. Materials should be categorized as per their use. Materials should be stacked in proper manner to maintain proper sequence of use. Closed stores should be constructed in order to avoid deterioration of any materials. Materials should be stacked as per vendor specifications. Materials should always be used in the sequence of FIFO. (First In First Out)

Workers should be made aware of government rules, policies, and concepts of waste management to minimize the amount of materials waste at construction sites.

4) Method of Execution of Works

Use of couplers in bar bending and placing should be made instead of keeping a lap length. Proper supervision is essential by engineer-in-charge. The workers should be made aware of latest technologies developed. To cut down the scrap produced, steel bars should be purchased in fixed lengths. In case of steel reinforcement, all the staff members including the departmental labor should be trained to work in a manner such that all steel scrap lying at site is collected and kept in the yard properly. Scrap produced from reinforcement should be separated lengthwise, diameter wise accordingly and small pieces be stored in empty cement bags or separate bins. Scrap can be sold regularly to cut down the material waste. Materials should be handled in proper manner and carefully. Good quality materials should only be used in order to reduce the waste. Plants and machinery should be cleaned after its use.

To cut down the amount of material waste, frequently re-handling of materials should be minimized. In case of materials like sand, aggregates, concrete platforms should be constructed to stack them. This in turn can cut down the amount of material left on the ground while shifting. Local materials should be preferred in order to cut down the delay due to non-availability of materials. Materials like bricks, stones, titles etc are required to be handled with carefully.

By implementing, all above suggestions for a site of flat construction by Company A, wastage of quantity of cement reduced from 4% to 2%, Brickwork by 5%, form work by 3% to 4% and steel by 2%. Saving in cost of sand and coarse aggregate was not considerable; otherwise, also cost involved of these two materials is very less in comparison of other costly materials like steel and cement.

REFERENCES

1. Howell, G.A. (1999)"What is Lean Construction". Proceeding Seventh annual Conference of the International Group for Lean Construction ,IGLC-7,Berkeley,CA,1-10
2. Koskela, L. (1992) Application of the new Production Philosophy to the Construction Industry. Technical Report No.72, Center for Integrated Facilities Engineering, Dept.of Civil Engineering, Stanford University, CA, September.
3. Dos Santos et al. (1998)."Principle of transparency applied in construction", Proc.of the Annual conf.(IGLC-6)by C. Formoso (ed).6th Conf. of Int. Group for Lean construction, Guaruja, Brazil, pp 16-23.
4. Kobayashi, I. (1995). 20 Keys to workplace improvement, Productivity Press, Portland,
5. Thomas H.R. and Sanvido, V.E.2000."The Role of the Fabricator in Labor Productivity "J.Constr.Eng.Manage.126(5), pp 358-365
6. Thomas H.R. Sanvido, V.Eand Sanders S.R. (1989)."Impact of Material Management on Productivity - A Case Study"J.Constr.Eng.Manage.115 (3), pp 370-384.
7. Thomas H.R. Horman M.D.de Souza U, and Zaviki,I (2002b) "Reducing Variability to Improve Performance as a Lean Construction Principle"J.Constr.Eng.Manage.128(2), pp 144-154
8. Thomas H.R.,Riley D.R.and JohnMessener (2005) "Fundamental Principle of Site Material Management ASCE Vol. 131(7) July 2005 pp 808-815.

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Table 1 : Details of Case Study

Name and Type of Company	Total Experience of the Company	Adopting the principals for last	Projects Handling	Specialization	Quality Accreditation	Means of Waste Identification	Perception about Waste
A Builders & Contractor	15-16 yrs	5-7 yrs	Housing Project	Government Servants Schemes Flat / Bungalow	In Process	Visual	Any waste occurring is a national wastage so wastages on site should not be permitted
B Builders & Contractor	17-18 yrs	7yrs	Flat System Commercial Complex	Flat/Bungalow	In Process	Visual	Some waste is inevitable. But all efforts should be done so as to reduce it.
C Builders & Contractor	20-22 yrs	10 yrs	Readymade Twin-Bungalow	Flat/Bungalow	ISO in Process	Visual	It is logistically difficult to manage Initially it needs awareness and cost for proper disposal. Government rules to be applied and implemented. Mostly not hazardous.
D Road / Bridges	15-20 yrs	5-7 yrs	Govt. Contract Works	Government Servants Schemes	NO.	Visual	Some waste is inevitable. But all efforts should be done so as to reduce it

Table 2 Percentage of wastage limit set by companies

	Company A	Company B	Company C	Company D
Cement	4%	2%	5%	4%
Sand (Fine aggregates)	5%	4%	10%	5%
Coarse aggregates - (10 mm)	5%	4%	10%	5%
Coarse aggregates - (20 mm)	5%	4%	10%	5%
Form work /Shuttering	N.A.	N.A.	5%	5%

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MS Steel / Reinforcement	3%	2%	3%	3%
Bricks	5%	10%	20%	5%

Table No. 3

Comparison of Planned Percentage of Wastage, Actual Percentage of Wastages and Total Percentage of Wastages.

SN	Materials	COMPANY A			COMPANY B			COMPANY C			COMPANY D		
		Planned % of Wastage	Total % Wastage	Actual % Wastage	Planned % of Wastage	Total % Wastage	Actual % Wastage	Planned % of Wastage	Total % Wastage	Actual % Wastage	Planned % of Wastage	Total % Wastage	Actual % Wastage
1	Cement (Bags.)	4	11	7	2	7	5	5	11	6	4	11	7
2	Sand (Cu. M.)	5	20	15	4	21	17	10	24	14	5	15	10
3	10mm Aggregate (Cu. M.)	5	17	12	4	18	13	10	24	14	5	15	10
4	20mm Aggregate (Cu. M.)	5	13	8	4	19	15	10	19	9	5	14	9
5	Formwork (Sq.m.)	-	5	5	-	7	7	5	14	9	5	12	7
6	Reinforcement (Metric Tons)	3	9	6	2	6	4	3	14	11	3	9	6
7	Bricks (Numbers)	5	18	13	10	28	18	20	39	19	5	23	18

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Table 4 Financial Details of Different companies

Case	Particulars	2009	2010	2011	2012
A	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
B	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
C	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
	Construction Work Done In Rs	5895630	12595405	19595955	34595905

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D	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