Evaluation of fly ash bricks, Steel and RMC by application of TQM in Residential Building Construction

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Abstract**—**Materials are the key resources in construction industry, since no production is possible without materials. It forms a major contribution of the cost of the construction and therefore proper control over their procurement, storage, issue, movement and consumption is necessary. Material of required quality and quantity is made available so that will be substantial saving in cost, time and also improve quality of construction. Material cost being in the range of 50% to 60% of the total cost of the project. Uncontrolled supply of material may result in excessive supply.

Total Quality Management (TQM) is one of the most popular modern management concepts.TQM is a quality management system which pursues excellence in customer satisfaction through continuous improvements of products and process by the total involvement and dedication of everyone involved in the process.TQM is a long term process and adopts strategic dimension. The aims of TQM are to achieve customer satisfaction, cost effectiveness, and defect free work through a relentless pursuit of the "war on waste. Customer satisfaction is achieved through focusing on process improvement, customer and supplier involvement, teamwork, training, and education.

This paper aim to evaluate the level of effectiveness of application of Total Quality Management principle, materials provided by supplier at S. J. Contracts Pvt. Ltd. Company. A qualitative research approach is adopted in this study, where the questionnaire is distributed to supplier. To stay competitive in today's market and maintain the quality of material is most important factor, so need to identify the level of quality practices in organization. Analyzed material quality by TQM application whether they follow the rules of total quality management or not, by maintaining the quality of materials, we achieved the quality of deliverables, therefore using the total quality management rules. For Further analysis, laboratory test on materials likes fly ash brick, steel, RMC are conducted. Materials are analyzed by using tools such as six sigma and benchmarking. Fly ash bricks analysis is carried and following results are obtained. The fly ash brick length is within expected benchmarked variation. The brick length is at 2 sigma performance. Considering Zero defect as the ultimate goal, then defect length is 25%. Material suppliers needs to more focus on the manufacturing process and quality of materials.

Keywords- *Total Quality Management, construction process, material suppliers' evaluation, six sigma, benchmarking*

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I. INTRODUCTION

The construction industry is one of largest industries in any country. It makes significant contribution to the national economy and provides employment to large number of people. During the past decades the construction industry has been criticized for its poor performance and productivity in relation to other industries. In construction, initial cost of the project is high and construction project management is more difficult than closing cost of project. The construction industry in many parts of the world suffers from problems such as workmanship defects, time, and cost overrun, poor health and safety, low productivity and inadequate quality. An unnecessary dispute arrives due to insufficient quality. A substantial amount of time, money and resource (materials) are wasted every year in the construction industry due to inefficient quality management procedures. To stay competitive in today's market, it is very essential for Construction Company to provide good quality of materials to owner and customer. This is achieved by application of TQM in construction sector. TQM provides excellence in customer satisfaction through continuous improvements of products and processes. TQM has been adopted by construction companies to solve the quality problem and meet the need of customer.

Providing customer satisfaction is a main objective of quality management. Material issued from supplier makes large impact on construction quality and the cost. Materials quality and measures provided by giving training to the materials suppliers about the advance manufacturing process and technology. In this paper three materials viz fly ash bricks, steel and RMC are selected for construction and laboratory analysis. The quality of materials are analyzed by using TQM tools such as six sigma and bench marking .Six sigma introduced by Robin Hood in 1980. It deals with measuring and improving how close we come to delivering on what we planned to do in construction industry. Analysis of quality parameters of materials for checking quality of the materials which used on the site.

II. OBJECTIVES

The main objective of this paper is to analyze manufacturing process and performance aspect of the materials viz fly ash bricks, steel, RMC provided and manufactures by the supplier using application of Total Quality Management in residential building construction through continuous improvement, bench marking and six sigma.

III. RESEARCH METHODOLOGY

Research Methodology is designed to meet the objective of the paper. Research Methodology follows the five processes

a) Site Selection
b) Data Collection
c) Material Selection
d) Application of TQM
e) Analysis and prediction using TQM

3.1 Site Selection

S. J. Contracts Pvt. Ltd. Is Construction Company which is working in residential construction project in Pune area. Data for this paper is collected from Jazz Phase II, Pune. Which project is under the scope of S. J. Contracts Pvt. Ltd. The project scope is RCC and brick work .Steel, RMC and fly ash bricks are used for construction work, so selected this site for evaluation of materials by application of TQM.

3.2 Data Collection

Material data is collected from Jazz Phase II site. Three construction materials selected that are Fly ash bricks, steel and RMC .These are important construction materials which has large impact on the project cost .Questionnaire survey conducted ,in which questionnaire distributed to material suppliers of the project. Their responses are analyzed. The Existing manufacturing process of Fly ash bricks, steel and RMC examined at suppliers Plant.

3.3 Material Selection

S. J. Contracts Pvt. Ltd. Company is working on Jazz Phase II site, Pune .The scope of the project is RCC and brick work. Three construction materials selected that are Fly ash bricks, steel and RMC. These materials used on site for construction work.

3.4 Application of TQM

TQM is one of the most popular modern management concepts**.** The aims of TQM are to achieve customer satisfaction, cost effectiveness, and defect free work through a relentless pursuit of the "war on waste. Customer satisfaction achieved through focusing on process improvement, customer and supplier involvement, teamwork, training, and education**.**TQM used to improve the quality of materials. Material evaluation by application of TQM tools such as six sigma and benchmarking. Quality parameters of the material analyzed by standard deviation, range, six sigma, benchmarking and inference noted.

3.5 Analysis and prediction using TQM

The Laboratory test is conducted on these three materials are Fly ash bricks, steel and RMC. Test reports are collected and quality of the material checked by using different types of tests. For fly ash brick test are water absorption analysis, compressive strength and dimension analysis. Steel- Tensile strength test, bend test, proof stress, rebend test etc. RMC- Compressive strength test of 7 and 28 days, slum cone test, gradation of fine and coarse aggregate.

Material analysis by application of TQM tools such as six sigma and bench marking. If any defect in quality of material occurred, it corrected by using TQM.

IV. PROJECT DESCRIPTION

Jazz Phase II site is residential building project. Which is shown in fig 4.1.This is located at Sr. No. 17/18 Pimple Nilakh, Pune. Kolte Patil Developers is the owner of the project and S. J. Contracts Pvt. Ltd. is Contractor for project. The Cost of the project is 37.19 crores .Project consist of two buildings A and B which is shown in fig 4.2 having two podium plus 19 story. The Scope of the project for contractor is RCC and brick work .Fly ash bricks fig 4.4 (a), steel fig 4.4 (b),and RMC fig 4.4 (c) are predominantly used material at this site, so that three materials viz fly ash brick, steel and RMC are selected for evaluation by application of TQM.

Fig 4.1 Jazz Phase II

Fig. 4.2 A and B building

Fig 4.3 A building

4.4(a) Fly ash Brick

4.4(b) Steel

4.4 (C) RMC

4.4 (d) Pouring of RMC

V. TOTALQUALITY MANGEMENT AND EVALUATION METHODS

Total Quality Management

TQM is a quality management system which pursues excellence in customer satisfaction through continuous improvements of products and process by the total involvement and dedication of everyone involved in the process.

ISO 9001 Facilitating TQM with following features

1. Customers focus :- Meeting customers requirements is the primery objective of TQM
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3. Leadership: leaders establish unity of purpose and direction of origination.
4. Involvement of people: People at all level are the essence of organization and their abilities to be used for the organization benefits.
5. Process Approach: A desired result is achieved more efficiently when activities and related resources are managed as process.
6. System Approach to management: Identifying, understanding and managing interrelated processes as a system contributes to the organization effectiveness and efficiency in achieving its objectives.
7. Continual Improvement: Continual improvement of the organization overall performance should be a permanent objective of the organization.
8. Factual Approach to decision making: Effective decision is based on analysis of data and information.
9. Mutually beneficial suppliers Relationship: An organization and its suppliers are independent and mutually beneficial relationship enhances the ability of both to create value.

Jazz Phase II site follows the ISO standardized rules and regulations. Quality of process and materials used at site is checked by the quality improving techniques like checklist. Checklist used in the auditing of quality assurance and to follow the steps in a particular process. Before using any materials on site, standard test are conducted and quality parameter of materials checked .If it is within the limit of standard then used on site otherwise material is rejected.

Material Evaluation

Selecting material for construction is important decision in company to maintain the quality of the work .Now a day market is changing fast, variety of materials available and selecting right quality of the material is essential. Selecting material is multi dimensional problem which include both qualitative and quantitative factors. For selecting material most essential criteria are quality of product, on time delivery and performance history of the materials.

Material evaluated by following way

1. Evaluating needs and defining objectives
2. Gathering information about material
3. Interviewing with material suppliers
4. Selecting material and applying TQM tool to check the quality of the materials.

This paper does not any co relation with the supplier evaluation methods. For selecting materials we need to known the supplier evaluation methods. The materials evaluation method based upon supplier evaluation are as follows;

Suppliers Evaluation Methods

1. *Decision Matrix Method (DMM)*

Decision matrix method is qualitative techniques. which was proposed by Pugh in1990.It consist of establishing asset of criteria upon which the potential options can be decomposed, scored and summed to gain a total score which can be then be ranked .The criteria are not weighted to allow a quick selection process. It is frequently used in engineering for making decision but can also be used to rank investment options, vendor's options, product options or any other set of multidimensional entities. Ranking method mostly used for material supplier evaluation. Good quality of material given higher ranking and low quality of materials given lower ranking.

2. *Decision Support Model(DSM)*

This is a multi-criteria decision model for supplier's selection as well as an efficient evaluation procedure for the selected

supplier. The model is used on simple multi –attribute rating technique exploiting ranking method [SMARTER].The main contribution of model is to structure the process of material supplier selection, establishing strategic policies on which the company management system relied to make the suppliers selection.

3. *Analytical Hierarchic Process (AHP)*

It is a decision making method for prioritizing alternative when multiple criteria and sub criteria must be used .It is developed by saaty in 1980 .It has been applied to the wide Varity of decision area ,including research and development project selection ,evaluating alternative product formulation, and selecting a micro computer. This method allows the decision makers to structure complex problem in the form of a hierarchy or a set of integrated level.

Generally the hierarchical has at list three levels ,The goal ,The criteria and alternatives ,as it is represented in figure .For the material suppliers selection problem ,the goal is to select the best overall supplier. It considered multiple criteria, quantitative as well as qualitative and allows them to integrate into the single overall score .The alternatives are the different proposals supplied by the supplier.

VI. DATA COLLECTION

Table 6.1showing the response of supplier for the questionnaire which was distributed to the material supplier.

Data analysis is analyzed on the basis of the supplier's response.

Each supplier have quality manual, quality parameters are printed on the manual provides with the materials. Quality assurance manual is mandatory for ISO certified suppliers. Some suppliers gives quality assurance but do not possess the quality assurances manual. Remaining suppliers don't know what the quality assurance manual. Materials which are produced in factories and workshops of supplier have documented procedure and details of work procedures for all operations.

Table 6.1

Sr. No.	Description	Yes	No	N/O
1	There is quality Assurance system That is properly implemented and documented	26	-	-
2	There is quality Assurance Manual (if Yes, Please send copy of your Manual).	13	7	6
3	There are documented procedure and detail work instruction for all operation which effect quality.	18	2	6
4	There is corrective action program that is implemented	26	-	-
5	The quality Assurance organization trains' and documents employees in the application of quality assurance method	16	-	10
6	There is calibration program for your test & measurements equipments	16	1	9
7	All of your tests are within calibration.	17	1	8
8	All the materials, parts and suppliers are rated upon receipt to assure conformance to all requirements	26	-	-
9	There is system for rating suppliers for quality and delivery	21	5	-
10	There is system for rating suppliers for quality and delivery.	21	1	4
11	Your measuring & test equipment is identified to indicate the last calibration date, by whom and calibration due date.	17	-	9
12	You Have Documented inspection system for incoming, in-process and final inspection.	23	1	2
13	You have documented self life program	3	18	5
14	Inspection records & traceability are provided with each other	26	-	-
15	Inspection records are kept for a minimum of 7 years.		22	4
16	All of discrepant materials are promptly and adequately identified and separated from normal all operations	26	-	6

Supplier who say no they don't have documented work procedure. The suppliers who don't manufacture materials say no. If any defect in the materials, supplier takes its own responsibility and defect removed by taking corrective action. The supplier having quality assurance organization trains their employees for improvement in the quality. Some suppliers are not the manufacturers of the goods; hence they don't need any quality assurance organization to train the employee. The suppliers who process manufacturing instruments, machineries and measuring instrument like weighing balance measurements tap etc. Have to fix a calibration schedule at least once a year. Some of the suppliers who do.

The supplier who have calibration program have said yes for the test result are within calibration ,the other supplier either don't know if there is any calibration programmer or they don't perform any calibration procedure. The supplier have rating system for their parent suppliers to ensure good quality of the produced goods or final product from the raw materials. Other supplier get license from the parent suppliers hence they don't rate their suppliers. The supplier sell the ISO certified product and goods and some of the suppliers like red bricks; aggregate suppliers don't follow the ISO certification. The supplier who perform the calibration programmer keep the record of the calibration date performed by whom next calibration due date .some of the supplier do regular calibration but don't keep record of it .While reaming do not perform the calibration procedure. The supplier keep inventory record showing quality of goods ,raw materials received .Then check the in process material and finally inspect final product .Some of the suppliers inspect the elements during this process but not keep the record in documented format. Shelf life means the period up to which a certain commodity can be stored till it becomes unfit for us .Materials like cement ,chemicals have an expiry date by suppliers and they should used within expiry date to achieve a certain quality .Inspection records and traceability of all the finished products and goods are kept by the suppliers for the purpose of ,if the quality defects arises ,it is easier to track down the source that whether it has come from parent suppliers or due to his own fault.

Following points are observed at the suppliers manufacturing plant of materials

The machine for fly ash is of the high quality and 90% mechanized and its production is 3 times more than the conventional mould machine, so Less manpower is required. Skilled labour is required for operating; they do not have

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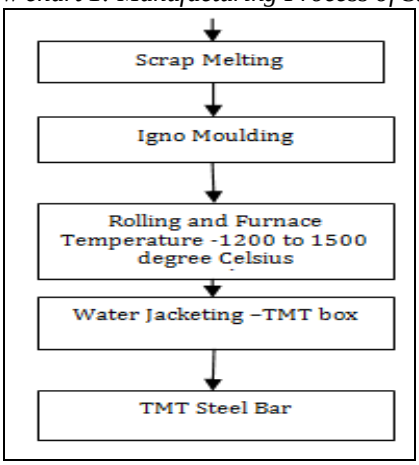
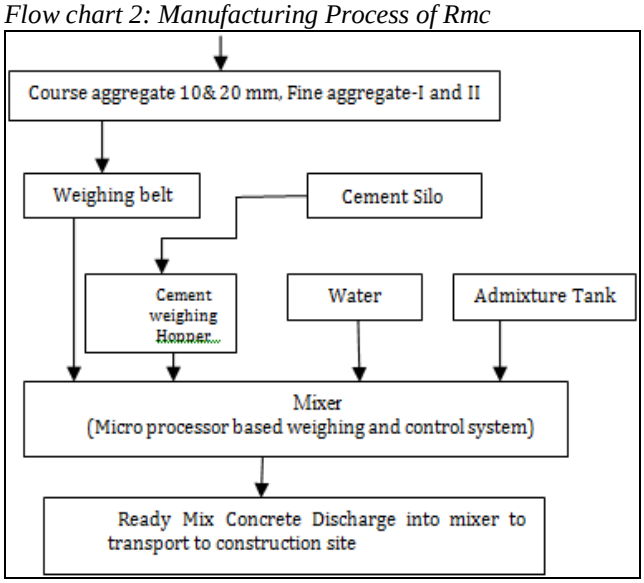
sufficient skill. Machine is economic for bulk production. Advanced technology based RMC manufacturing plant is used on site. Skilled labors for operating the plant. Good quality of RMC manufactured and transported to the construction site for concreting purpose. RMC quality is maintained by using good quality of the materials viz cement, Fine and coarse aggregate and admixtures.RMC manufacturing plant is located where the raw material easily accessible. All important factors for running the plant such as labour required, land required for storage of materials, road access easily available from surroundings.

Manufacturing of the steel materials more care is required. Skilled labors, latest equipment and machineries are available at plant. There is proper technical supervision during manufacturing process which ensures good quality

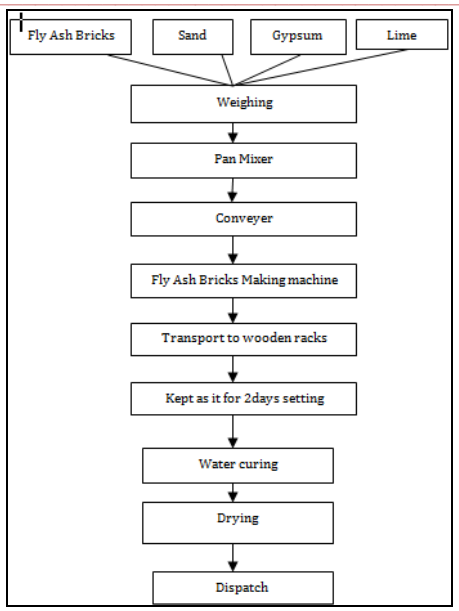
Flow chart 1: Manufacturing Process of Steel



Flow chart 2: Manufacturing Process of Rmc



Flow chart 3: Manufacturing Process of Fly Ash Bricks



VII. DATA ANALYSIS

Data analysis for the fly ash bricks, each parameter of Fly ash bricks such as length, width and compressive strength is analyzed with the help of total quality management tools such as Benchmarking and six sigma.

Fly ash bricks (sample analysis is given in Appendix B Table)

FLY ASH BRICKS

BRICK SIZE -220MMX100MMX70MM

SR NO	X (Length)	x (Mean of L)	(X-x) (difference)	(X-x)2
1	221.9	220.525	1.375	1.8906
2	220.8		0.275	0.0756
3	218.5		-2.075	4.1006
4	221.5		0.975	0.9506
5	221.8		1.275	1.6256
6	220		-0.525	0.2756
7	220		-0.525	0.2756
8	220		-0.525	0.2756
9	220		-0.525	0.2756
10	220		-0.525	0.2756
11	222		1.475	2.1756
12	221		0.475	0.2256
13	219		-1.525	2.325
14	220		-0.525	0.2756
15	221		0.475	0.2256
16	220		-0.525	0.2756
17	220		-0.525	0.2756
18	223		2.475	6.1256
19	218		-2.525	6.3756
20	222		1.475	2.1756
			TOTAL	30.4775

Range (R) =largest value – smallest value =5 mm

Standard Deviation (σ) = √ (Є(X-x) ²/n) = 1.234 mm comparing these with expected length of 220 mm

% **σ** = 1.234/220X 100 =0.56 which is very less.

Coefficient of variance (C.V) = σ/x =0.005598=0.55 %

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Variance (V) = (σ) ² =1.522

Consider set data is based on the benchmark expected variation: X ±1σ = 220.52 ± 1.234 =219.28 to 221.75

The total no of observation in this range is = (15/20) x100=75%

Inference-

1. The fly ash brick length is within expected benchmarked variation
2. Considering Zero defect as the ultimate goal ,then defect length is =25%
3. The brick length is at 2 sigma performance.
4. A correlation between crushing load and c/s area is 0.364 is low which show weak and positive correlation. (Shown in Table-7.2).

Table 7.2
Correlation coefficient for crushing load and cross sectional area.

SR NO	Y	Y	(Y-y)	(Y-y)²	X	X	(X-x)	(X-x)²	(Y-y) (X-x)
1	144.5		-36.06	1300.32	33982		89.53	8015.62	3228.45
2	139.1		-41.46	1718.93	34041		148.53	22061.2	6158.053
3	216.3		35.74	1277.35	34112		219.53	48193.4	7846.00
4	203.4		22.84	521.666	34153		260.53	67875.9	5950.50
5	118.8		-61.76	3814.3	34149		256.53	65807.6	15843.29
6	213.83		33.27	1106.89	33750		-142.47	20297.7	4739.9
7	213.83		33.27	1106.89	33750	33892.50	-142.47	20297.7	4739.9
8	101.98		-78.58	6174.82	33750		-142.47	20297.7	11195.2
9	191.8	180.56	11.24	126.338	33750		-142.47	20297.7	1601.36
10	185.5		4.94	24.4036	33750		-142.47	20297.7	703.801
11	219.3		38.74	1500.79	33750		-142.47	20297.7	5519.28
12	200		19.44	377.914	33750		-142.47	20297.7	2769.61
13	181.3		0.74	0.5476	33900		7.53	56.7009	5.572
14	181		0.44	0.1936	33900		7.53	56.7009	3.313
15	197.9		17.34	300.676	33900		7.53	56.7009	130.57
				=19351.97				=354208	=70434.8

Considering Y=Crushing load

X= C/s area

Standard Deviation (σ x) =√€(X-x) ²/n=390.186

Standard Deviation (σ y) =√€(Y-y) ²/n=12.0682

Cov (X, Y) = 1/n (€(X-x) (Y-y)) =1714.12

Correlation coefficient R = Cov (X, Y)/σ x .σ y = 0.364

A correlation 0.364 is low show weak and positive correlation between crushing load and cross sectional area.

IV. Conclusion

- This Paper evaluates the process and performance aspect of the materials manufactured by supplier based on the TQM principle such as six sigma, bench marking and continuous improvement. Supplier material is not effective with respect to the material requirement on construction Project.
- Manufacturing process conducted on Fly ash bricks, steel and RMC indicate that improvement is needed to solve the quality issue.
- Laboratory test result of fly ash brick indicates that material suppliers need to focus more on manufacturing process of materials as the performance of the material is very low, performance level is 2 sigma and defect length is 25%. A correlation between crushing load and c/s area is 0.364 is low which show weak and positive correlation.
- Questionnaire survey indicates that material suppliers need to focus on the quality aspects .They need to focus more on documented procedure and detail work instruction for all operations which affects quality manufacturing process of materials. Application of TQM tool helps continuous improvement, Benchmarking, involvement of all people, six sigma ,Calibration programme, Training to the workers of new technology , new equipment ,training to worker to develop better quality of work ,ISO requirement ,Corrective action programme and inspection record used to improve the quality of materials.

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