

Study and Analysis of Material Procurement and Supplier Selection for Residential Building Site

^[1] Chaitali Isal, ^[2] Dr. Shrikant Charhate

^[1] M.E. Research Scholar, Department of Civil Engineering, PHCET, Rasayani, 410207, India

^[2] Professor, Department of Civil Engineering, PHCET, Rasayani, 410207, India

Abstract: -- In civil engineering construction projects, the cost of material can vary from 50-60% of the total project cost. It is important to manage productivity, cost and effective material procurement. An essential factor affecting the performance of construction projects are improper material procurement and supplier selection which have a great impact on the quality as well as the profitability of the contractor. The purpose of this study is to find an increase in the cost due to improper material procurement and selection of suppliers. This study also suggests the better methodology for selection of suppliers and material procurement by generating strategies to improve, especially in residential building projects. For faster and proper supplier selection computer program was developed in C++ which will reduce the overall time of the project. The methodology applied was a collection of data in terms of planned and executed quantities for individual activities. The difference in procured material and actually executed materials was calculated to find the extra material procured. It was observed that sudden shortage of material from primary selected suppliers caused immediate call for material from other suppliers which increased the overall cost of the project. Overall increased cost was 13,48,882 for the period of 12 months of study and cost analysis observed 1.5% hike on the total cost of material for this project.

Keywords: - Material Procurement, Supplier Selection, Construction Materials, Residential Building Site, Computer Programming.

I. INTRODUCTION

The optimization of inputs can be any of the M's. Reduction in manpower is usually not entertained. Reduction in machines is also not easy since, due to the continuous increase in the price of machines and in order to the competitive world, old machines are to be replaced with new ones due to technological advances. Hence the only area in which change in the economy is possible is with the material. Avinash Shukla et al. through their research stated that Material indicates prime expenses in a construction, so the overall cost can be reduced by controlling procurement cost. Construction materials contribute about 40-50% of the total cost of the construction project estimated by Construction Industry Development Council of India (CIDC) [1]. Anwar Zeb et al. explains construction projects passing through the various phases i.e. initiation, planning, implementation and closure may have the problems of material management [2]. Furthermore, it has been noticed that large quantities of building materials are allowed to be buried each year due to the inadequate controls on project site. Procurement is the acquisition of goods or services at the best cost, in the right quality and quantity, at the right place and time for the contractor. Abundant problems arise

in procurement of material during various stages of project life and the reason for problems systems of material procurement of contracting organization. Many a times excess of materials when stored on site without proper planning they tend to get deteriorated unless special care is taken. Delays, shortage and extras expenses can be incurred if materials required for particular activities are unavailable in material procurement. Ar. S. Kamalaeaswari et al. termed procurement as it encompasses a wide range of activities that includes purchasing of equipment, materials, labor and services required for construction and implementation of a project and objective of procurement in materials management is to provide the materials in the right time, place, quality and an agreed budget [3]. Hemanta Doloi et al. finds that inefficient site management is certainly another key factor affecting the cost of the project. Improper procurement leads to the financial problem of a contractor is the most important cause of cost and time overrun [4]. Muriro et al. analyzed procurement in construction concluded that the other methods of procurement were complex and the traditional method is easy and gives effective outcomes with an increase in project life [5].

G.T.N. Veerendra et al. has analyzed different procurement processes, suggested a particular procurement route having the most successful ratio for construction project justified by qualitative and quantitative approaches [6]. Natasa Turina et al. explained that it would have been better if traditional method of procurement was used to the maximum possible extent. The advantage of this method found was that it had the least risk and so was recommended to use traditional procurement as most suited for small scale industry projects [7]. Ma et al. studied that it is essential to establish different relationships with different material suppliers which mean that the assessment methods are dependent on the type of material purchased. Therefore, in order to select suppliers who continually outperform the competition, suppliers must be carefully analyzed and evaluated [8]. Mastura Jaafar et al. studied the methods of procurement in public and private construction sector concluding no best procurement method to be recommended whereas many contractors used traditional method [9]. Construction industry recognized some supplier evaluation and selection criteria as the most important ones [10]. Ensuring a timely flow of materials is the key challenge in the material procurement management and selection of suppliers.

II. METHODOLOGY

This study focused only on residential construction building project. The survey helped to obtain specific information regarding the improper supply of material to the site which called out for detailed study of the material procurement process. Identification of problem involved in material procurement and supplier selection process were carried out through different ongoing site case studies and process for residential base building construction and the finishing works. The case study site Tulsi estate at Neral was selected on the basis of general observation and discussion with the professionals. It included data collection and observation on project schedules, analysis of the materials, the process of selection of suppliers and the general process of material procurement. The data collected showed the key problems in material procurement and its causes and effect on the total cost of the project. This study allows to collect various data from an ongoing site, particularly which relates to material procurement and supplier selection involving their respective processes, approvals, purchase quantitative and qualitative reports of materials and suppliers, follow-up reports, if needed claim reports, delivery reports and individual supplier details. The information gathered from these details and from the literature studies, improvisation in the strategies was obtained and proper approach to the

material procurement process and supplier selection was proposed for the residential buildings. Effective material procurement gives company many benefits such as reduction in overall material cost, better material handling, elimination of order duplication, improvement in labour productivity, up-gradation of project scheduling, quality control and better material control. It also involves reduction of storage for materials, problems of labour savings, overall stock reduction, better management of cash flow, and material surplus reduction. Material procurement mainly involves the best relationship with the supplier which is an important benefit for contractors as well as company.

2.1 Procurement Plan

Procurement components were combined to form a procurement approach based on contractor's project goals and objectives. Innovative procurement approaches are combinations of new or established procurement components to produce a novel procurement approach. The purchase plan, which involves physical activities, is prepared after taking into consideration the material requirements spread out on a time chart. The contractor from this could be able to understand the exact quantity of the material required for procuring after the planning stage. Procurement action can then be planned on a systematic basis as shown in Fig 1.

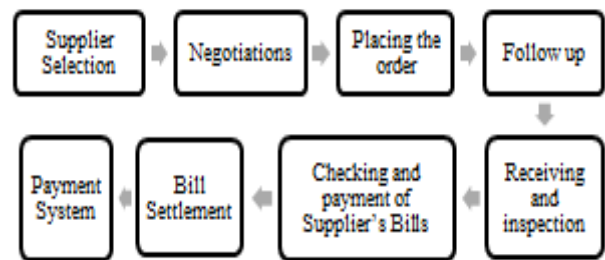


Fig 1: Flow Diagram of Procurement Plan

2.2 Supplier Selection Process

The initiation of supplier selection starts by choosing potential suppliers for each type of material for a specific project. In general, past performance of suppliers is a key criterion in the selection process. Therefore, in order to select suppliers who continually outperform the competition, suppliers must be carefully analyzed and evaluated. The process of supplier selection involves seven major steps that were needed for supplier selection, identification of key sourcing requirements and criteria, determination of sourcing strategy, identification of potential supplier sources, limit suppliers in the pool,

determination of methods for final selection, and final supplier selection.

The criteria's for supplier selection were quality, capacity, delivery, cost, payment credits and location of the supplier and quoted suppliers were selected accordingly for their respective material. The supplier with fulfillment of maximum criteria was selected as main supplier by procurement cell of contractor.

III. DATABASE AND ANALYSIS

3.1 Data Collected

Data was collected from the site of Tulsi estate, Neral for item work of concreting and finishing works in planned and executed quantities of external plastering, internal plastering, concreting work, siporex block work (625x250x150mm), siporex block work (625x250x100mm), fly ash brickwork (230x150x100mm), fly ash brickwork (230x100x100mm). Concreting work was studied for 7 months from August 2014 to April 2015. Finishing work was studied for 12 months from August 2014 to August 2015. Collected data was later segregated in such a way that the material quantities were calculated for their respective item work according to planned and actual quantities. Quantity of cement, fly ash, crushed sand, 10mm aggregate, 20mm aggregate, admixture, water were calculated for concreting work and for external and internal plastering, cement and sand quantities was calculated. Brick, sand and cement was calculated for fly ash brickwork and siporex block for siporex blockwork. The procurement approaches adopted by procurement cell for considering materials on this site are shown in Table 1.

Table 1: Types of procurement approach used in study

Sr.No.	Material	Type of procurement
1.	Cement	Invitation to negotiation (ITN)
2.	Sand	Pre-qualification and negotiation
3.	Aggregate	Pre-qualification and negotiation
4.	Flyash bricks	Invitation to negotiation (ITN)
5.	Siporex blocks	Invitation to negotiation (ITN)

3.2 Monthwise Details of Materials

Monthwise details of materials required for finishing items work and concrete work was calculated. Supplier selection was done on the basis of fulfillment of maximum criteria. There were number of quoted suppliers and many of them

were used for supplying materials. The need of secondary suppliers was more for maximum months as capacity of main supplier was over. Monthwise details of concrete materials supplied by suppliers were calculated. From these calculations it was seen that there were number of quoted suppliers and many of them were used for supplying materials. Except cement suppliers, all primary suppliers of remaining materials supplied materials in all months. The Vasavdatta company, supplier of cement directly supplied cement in bulks. Hence, when there was no bulk quantity it was not feasible to procure material from supplier. Hence, required material was procured from other suppliers of cement where they charged higher than the primary suppliers resulting in the increase of cost.

3.3 Unit rate (Rs.) of each supplier

The rates of materials procured from various suppliers for finishing and concreting work in this project from September 2014 to August 2015 was studied and calculated. Different suppliers had varied unit rates for different months. Whenever incomplete delivery of material or in failure of primary suppliers materials were procured from other eligible suppliers, but in this case the secondary supplier charged on the higher side as shown in the Table 2.

Table 2: Monthwise details of concrete materials supplied by various suppliers

Sr No	Material	Supplier Name	14-Sept	14-Oct	14-Nov	14-Dec	15-Jan	15-Feb	15-Mar	15-Apr	15-May	15-Jun	15-Jul	15-Aug
1	Cement (Bag)	V.T. Balasubh Company	240	240	250	250	255	255	260	260	270	280	280	300
		S.P. Desai's					280	280	290		300			
		Vilas & Co								270				
2	River Sand (Bass)	Aarya sand supplier	5000	5300	5300	5700	5700	5800	5800	5875	5900	5900	6000	
		Parad Est						5900	5900	5900	6000			
		Sunil Est				5500	5500		5690	5700		5740		
		Pank Est												
		Athava Supplier												
3	4" Fly Ash Bricks (Nos)	Bhoomi Developer	3	3	3.5	3.5	3.5	5	5	5	5	5		
		S.V. Associates								5	5			
		S.I. Associates								4.5				
		Shoraga Est								4.5	4.5			
		Aarya Bricks	3	3	3.5	3.5	3.5	4	4	4	4.5	5	5	
		Pank Est												

3.4 Data Analysis

Data was analysed for every individual material used in concreting and finishing work. The analysis concluded that the procurement of grade 53 cement was carried out for 6 months from secondary supplier out of 7 months. In case of crush sand, 10mm, 20mm aggregate and fly ash procurement from secondary supplier was done for 6 months, 4 months, 3 months and 3 months respectively out of 7 months for concreting work. Failure in the primary suppliers and reasons was less number of selected suppliers,

unavailability of materials from the main supplier, trend of increasing rates by secondary suppliers was more and location of secondary supplier was out of Maharashtra in case of cement. Data analysis carried out for finishing work for every material was concluded that the procurement for cement grade 43, river sand, flyash bricks and siporex block was carried out by the secondary supplier was 5 months, 4 months, 7 months and 5 months respectively out of 12 months. The reason for less supply and procurement from secondary supplier was that the capacity of primary supplier was over and the capacity of one of the secondary supplier with competitive rate was also over, other secondary suppliers were not competitive. Contractor was not able to procure bricks as monthly budget got affected. Immediate supply for the ongoing construction site was needful, hence contractor had to procure materials at non-competitive rates from other suppliers which affected the monthly budget of the site and resulted in increase in total cost of the project.

IV. RESULTS AND DISCUSSION

4.1 Supplier Selection

Selection of suppliers was done on the basis of some criteria which was set by the contractor and based on quality, capacity, delivery, cost, payment credits and location of the supplier. The supplier fulfilling maximum of the criteria was selected. The selected supplier list is shown in Table 3.

Table 3: List of Selected Supplier

Material	Primary supplier selected	Description
Cement	V.T.P Company	Selection was done because they fulfilled all criteria and were competitive in unit rates and supply terms were good.
River sand	Arya sand supplier	As they were good in rates and supply terms but even Prasad enterprises were selected as secondary supplier because they had high of rate.
Fly ash bricks	Arya Bricks	They provided with competitive rates. Along with them Bhoomi developer, they had high rates but abundant supply.
Siporex Block	Citadel ecobuild	The main advantage was location in the site and they fulfilled all supply terms

4.2 Analysis of supplier Selection by programming

Analysis of supplier selection of cement is done by using computer programming in C++. In this comparison is done between the selection done by the contractor and the

program developed. The parameters inserted in program as an input are the same parameters which are selected by the contractor during the selection process. This program is flexible for all kind of projects, where the parameters are to be decided by the selection committee of the contractors. This program is working on the scoring system which means every individual criterion would have their own points. Supplier having maximum points at the end of calculation would be the selected supplier suggested by the program. The input data added for the comparison are shown in Fig 2 where sentence 1 shows the criteria of the supplier and sentence 2, 3 and 4 shows the data of quoted suppliers. All the criteria and data are separated by commas. Result obtained from the program is shown in Fig 3. S.P Traders are selected suppliers by the program for cement.

```

1 #
2 Contractor Name, Quality of Material, Max Capacity To Supply (in months), Delivery to site (in days), Cost, Payment
3 Credit (in days), Location
4 1. V.T.P, Very Good, 12, 9, adequate, 30, near
5 2. Atlas & Company, Very Good, 20, 8, adequate, 30, away
6 3. S.P Traders, Excellent, 25, 5, inadequate, 30, near

```

Fig 2: Input data

```

cpp $ g++ shortlist_supplier.cpp -o shortlist_supplier_compiled
cpp $ ./shortlist_supplier_compiled
Selected Contractor is - S.P Traders
cpp $

```

Fig 3: Result of supplier selection

4.3 Cost Analysis

The methodology for cost analysis of supplied materials for concrete work over the 7 months and finishing work over 12 months was found for particular months where there was increase in the cost of procurement of considered materials due to uncompetitive secondary suppliers rates. This includes the quantities of that particular month supplied by secondary suppliers for respective materials.

Cost Analysis done on the data which shows the total increase in the procurement of the material is Rs. 13,48,882 in Table 4.

Table 4: Increase in cost of Individual Material

Sr.No.	Material	Increase in cost (Rs)	Month of Procurement
--------	----------	-----------------------	----------------------

1.	Cement 53 grade	5,20,600	7 Months
2.	Crush sand	1,02,660	7 Months
3.	Fly ash	22,000	7 Months
4.	10mm Aggregate	14,890	7 Months
5.	20mm Aggregate	24,580	7 Months
6.	Cement 43 grade	1,81,200	12 Months
7.	River sand	30,600	12 Months
8.	4" Fly ash Brick	59,902	12 Months
9.	6" Fly Ash Brick	2,51,100	12 Months
10.	4" Siporex Block	18,000	12 Months
11.	6" Siporex Block	1,23,350	12 Months
	Total	13,48,882	

Maximum Increase was observed in cement (grade 53), cement (grade 43), 6" fly ash brick and crush sand shown in Fig 4.

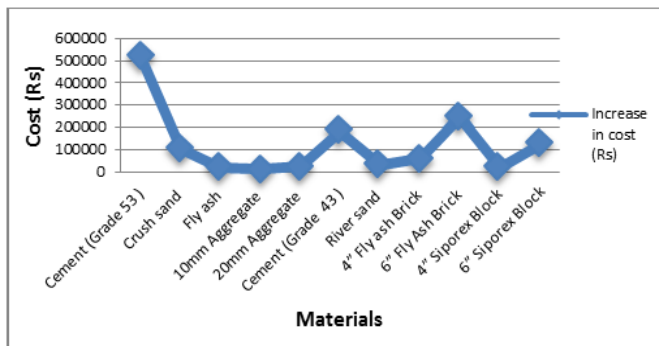


Fig 4 Increase in cost (Rs)

The difference between original cost due to secondary suppliers and cost due to primary supplier gives increase in cost.

Example:

Suppose Supplier A gives 10 bags for Rs.300/bag & Supplier B gives 10 bags for Rs.310/bag.

Increase in total cost: 3100-3000= Rs.100

Total increase in procurement process was calculated by multiplying rate and quantity which was found to be 1.5% increase in original cost of estimation as shown in Table 5. Calculation marked the high increase percentage of 6" fly

ash brick cement, cement (grade 53), cement (grade 43) and crush sand shown in Fig 5.

Table 5: Increase in the Total Cost

Sr.No	Material	Original cost of Procurement Rs.	Actual cost of procurement Rs.	Percentage increase
1.	Cement (43 grade)	9969500	10150700	1.81%
2.	River sand	11644375	11674975	0.31%
3.	4" Fly Ash Bricks	828100	888002	1.94%
4.	6" Fly Ash Bricks	1290285	1541385	7.23%
5.	4" Siporex Blocks	1561685	1579685	1.15%
6.	6" Siporex Blocks	7367220	7490570	1.67%
7.	20mm Aggregate	8021050	8045630	0.30%
8.	10mm Aggregate	4031000	4045890	0.36%
9.	Crushed sand	11738800	11841460	0.88%
10.	Fly Ash	2572400	2594400	0.85%
11.	Cement (53 grade)	29018500	29539100	1.79%
	Total	88042915	89391797	1.50%

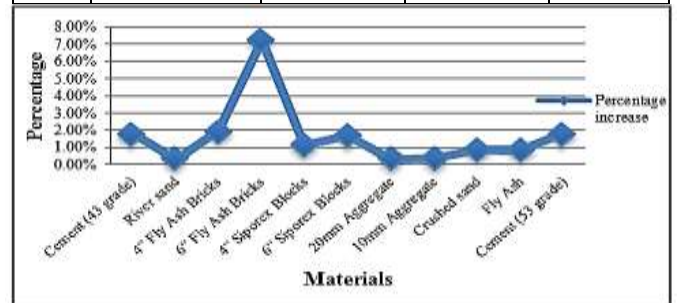


Fig 5 Percentage Increase

Small change in the cement percentage will affect more on total cost as the unit rate of cement bags is more as compared to fly ash brick. Hence the cost analysis graph Fig 6 shows more effect on cement grade 53 as compared to 6th fly ash bricks.

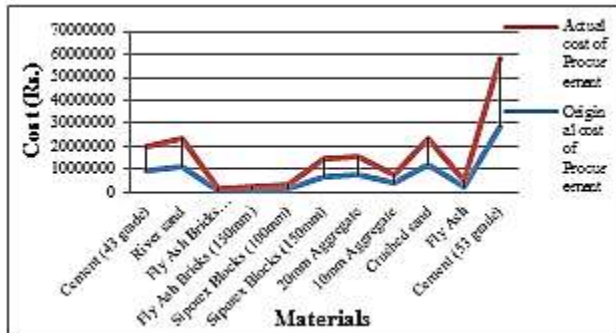


Fig 6 Cost Analysis Graph

IV. CONCLUSIONS

There was an inadequate supply of materials in certain months though the orders were placed in advance, due to which delay occurred in total time of construction project. This was because of improper procurement planning and procedure of supplier selection. There were huge quantities of concrete work and finishing work, for this the primary suppliers selected by procurement cell of contractor had limited capacity. After the capacity of primary supplier was over, secondary suppliers supplied materials for few months. Hence due to uncompetitive rates, department procured materials in limited quantities from secondary suppliers which resulted in less supply of materials and high cost which increased total cost of the project. One of the major reasons for less supply of cement was less number of suppliers selected. The procurement department was failed to recognize the monthly capacity of cement suppliers. This resulted in the delay of work and high cost in procurement from other supplier. There was an increase in the cost of procurement of all materials in certain months hence, total increase in the cost of procurement was 1.50%. The cost analysis of finishing works materials shows that increase in the cost of procurement of fly ash bricks was more as compared to other materials. This was also due to primary supplier's failure in the supply of materials and secondary supplier's rate was affected by a monthly budget of the procurement department. Hence they did not procure required materials from secondary suppliers. The percentage increase for cement was also 1.81%. The cost of cement is more hence small increase in the cost of a percentage of cement will affect the daily work progress. The summary of

data analysis shows that total increase in cost for procurement of materials in 12 months was of Rs.13, 26, 882. Quick method used for selection of supplier was done by computer programming using C++ where selection was not done only on the basis of least rate challenged but also on capacity, quality, location and credits for payment. Improper selection of supplier and procurement method for material raised final cost of the project.

REFERENCE

1. Avinash Shukla, Dr Mohd Afaq Khan and Dr Mrinalini Shah, "Literature Review Of Adoption Of E Procurement Practices By Construction Industries", AIMA Journal of Management & Research, vol.10, no.2/4, pp. 1-25, 2016.
2. Engr. Anwar Zeb, Engr. Sohail Malik, Dr. Shazia Nauman, Engr. Hashim Hanif and Engr Muhammad Osama Shahbaz Amin, "Factors Affecting Material Procurement, Supply and Management in Building Projects of Pakistan: A Contractor's Perspective", Proceedings of 2015 International Conference on Innovations in Civil and Structural Engineering, pp. 170-175, 2015.
3. Ar. S. Kamalaeaswari, Ar. B. Vedhajanani, "Process Analysis of Material Procurement in Commercial Buildings and Recommendation", International Journal of Engineering Research & Technology, vol. 4, no. 3, pp. 1106-1010, 2015.
4. Hemanta Doloi, Anil Sawhney, K.C. Iyer, Sameer Rental, "Analysing factors affecting delays in Indian construction projects", International Journal of Project Management, vol. 30, no.1, pp 479-489, 2012.
5. Muriro, A and Wood, GD , "A comparative analysis of procurement methods used on competitively tendered office projects in the UK", The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors, pp 1-16, 2010.
6. G.T.N. Veerendra, Ch. Durga Prasad, A.Girish Baburao, "Procurement-principle towards effective management of construction projects", International Journal of Research in Engineering and Technology, vol. 3, no. 6, pp 624-629, 2014.
7. Natasa Turina, Malden Radujokvic, Diana Car, "Design And Build" In Comparison With The Traditional Procurement Method And The Possibility Of Its Application In The Croatian Construction Industry", 8th International

**International Journal of Engineering Research in Mechanical and Civil Engineering
(IJERMCE)**

Vol 3, Issue 1, January 2018

Conference: Organization, Technology and Management in Construction , pp 1-8, 2008.

8. Ma, L and Yang, G, “The selection of construction material suppliers in supplier relationship management (SRM)”, Proceedings of the 2010 International conference of information science and management engineering, IEEE, pp 189-192, 2010.

9. Mastura Jaafar1 and Azlan Raofuddin Nuruddin,”The development of public and private construction procurement systems in the Malaysian construction industry”, Journal of Design and Built Environment, vol. 11, no. 1, pp 1-11, 2012.

10. Ho, C and Nguyen, “Supplier evaluation and selection criteria in the construction industry of Taiwan and Vietnam”, International journal of information and management sciences, vol.18, pp. 403-426, 2007.

