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Material Management by Inventory control Techniques by Apartment Building as Case Study

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Abstract: ***Construction material constitutes the major cost component in many construction projects, the total cost of installed material may be 50% or more of the total cost. Materials represent major expenses in construction. Delay and expense may be incurred if material required for particular activity. Ensuring a timely flow of material is an important concern of material management. The goal of material management is to ensure that the materials available at their point of use when needed. Hence, efficient procurement of material represents a key role in the successful completion of the construction work. The main purpose of this project to find the variation in planned vs actual material cost through A-B-C & E-O-Q analysis and applying inventory material management so as to minimize stock out problems and minimize the total cost of the construction project.***

Keywords: material management, procurement, inventory control techniques, A-B-C analysis

I. INTRODUCTION

The cost, time & quality are the important objective of material management. Cost is an important parameter of any project. The material availability at right cost is key for economy of project. If material is purchased too early, capital gets tied up as well as ,interest charges incurred on excess inventory of material .On other hand if material availability at site is delayed it will affect scheduling of activities. Time is important

parameter of any project. Material should be available in hand at right time for successful completion of project. Men & machinery become ideal if material is not available on time further it increases the time of completion of project. Quality is an important factor for any project. Quality of construction can be achieved by procuring standard.

Construction material constitutes a major cost component in any construction project. The total cost of installed material may be 50% or more of the total cost. The goal of material management is to ensure that the materials are available at their point of use when needed hence, efficient procurement of material represents a key role in the successful completion of the work. Materials management is a critical component of the construction industry. As such, organizations need to understand the effects of proper materials management techniques on the effectiveness of project execution. Extensive literature and reports deplore the lack of efficiency and productivity in the construction industry. Too often, construction projects suffer from delays, budget overruns, and claims. A properly implemented materials management program can achieve the timely flow of materials and equipment to the jobsite, and thus facilitate improved work face planning, increased labor productivity, better schedules, and lower project costs.

II. RESEARCH METHODOLOGY

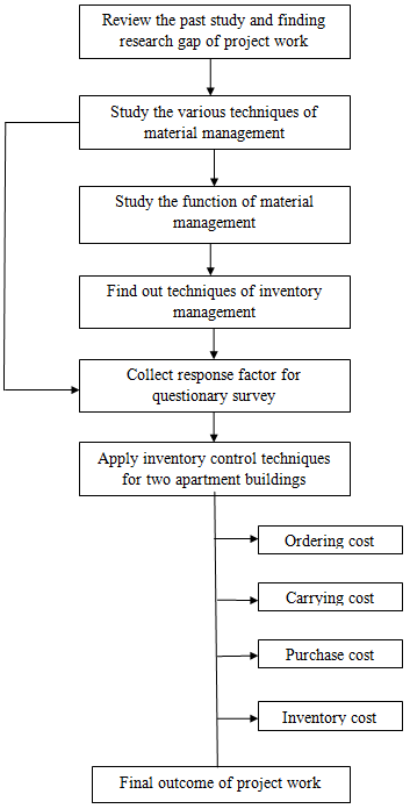

Figure 1 Flowchart of Methodology

III. PAST STUDIES

Salawati Sahari, Michael Tinggi and Norlina Kadri, (June 2012) Managers act rationally in managing their inventory efficiently if they are convinced that the practice enhances firm performance. However, extant research in operations management has revealed divergent insights into the inventory-performance link. This study empirically examines the relationship between inventory management and firm performance and capital intensity on a sample of financial data for 82 construction firms in Malaysia for the period 2006–2010. By employing regression and correlation techniques, it was found that inventory management is positively correlated with firm performance. In addition, the results indicate that there is a positive relationship between inventory management and capital intensity

Khyomesh V. Patel, Prof. Chetna M. Vyas, (2011) This paper is written to fill a void created by the absence of proper materials management on construction sites. To managing a productive and cost efficient site efficient material management is very essential. Research has shown that construction materials and equipment may constitute more than 70% of the total cost for a typical construction project. Therefore the proper management of this single largest component can improve the productivity and cost efficiency of a project and help ensure its timely completion. One of the major problems in delaying construction projects is poor materials and equipment management. This paper describes the main results of survey carried out in Ahmedabad that investigated the material management of 3 well known builders of Ahmedabad.

Small and medium sized enterprises (SMEs) represent a large part of the construction sector. Large companies have the capacity and capability to use sophisticated information technology and management technology to control the labour and materials on projects. SMEs need help to implement control systems for labour and material that will improve performance on site. *Sohrab Donyavi and Roger Flanagan, (2009)* The research involves investigation of the impact of effective material management for SMEs on construction sites. Consideration is given to materials' flow through the supply chain up to installation on site. Materials can represent up to 70% of the project construction cost, hence any ways to reduce wastage and improve productivity will have major cost and time benefits. Now technologies can help in the management of materials flow and benefit contractors with lower costs and clients lower prices. The aim of this paper is to describe how SMEs can improve their performance in materials management, to reduce their costs, and to improve the project delivery. Case study and interview has been used as the research method to develop the ideas in this paper.

Construction materials management is generally recognized to be the integrated coordination of materials takeoff, purchasing, expediting, receiving, warehousing and distribution. When these functions are not properly managed, materials shortages, surpluses, and cash flow problems are likely to occur. Costly labor delays result when the required quantity or quality of materials are not available when needed. *Lansford C. Bell1 and George Stukhart (1986)* The

attributes of materials management systems are discussed and the essential elements of a successful system identified. Owner-contractor, engineer-contractor, and home office-project site communications appear to be critical to the success of the materials management effort. Preconstruction materials planning and personnel orientation and training are also important. The complex on-line computer programs that are used to coordinate the materials management effort are costly, but essential, if the desired degree of control is to be exerted to prevent potential shortages, surpluses, and cash flow problems.

IV. THEORY

3.1. Inventory Management - Definition and Concepts

There is need for installation of a proper inventory control technique in any business organization in developing country in India, inventory management refers to all the activities involved in developing and managing the inventory levels of raw materials, semi-finished materials and finished good so that adequate supplies are available and the costs of over or under stocks are low. The cost of maintaining inventory is included in the final price paid by the consumer. Good in inventory represents a cost to their owner. The manufacturer has the expense of materials and labor.

Inventory as a stock of possessions is maintained by a business in expectation of some of the future demand. This definition was also supported who stressed that inventory management has an impact on all business functions, particularly operations, marketing, accounting, and finance. He established that there are three motives for holding inventories, which are transaction, precautionary and speculative motives. The transaction motive occurs when there is a need to hold stock to meet production and sales requirements. A firm might also decide to hold additional amounts of stock to cover the possibility that it may have under estimated its future production and sales requirements. This represents a precautionary motive, which applies only when future demand is uncertain. The speculative motive for holding inventory might entice a firm to purchase a larger quantity of materials than normal in anticipation of making abnormal profits. Advance purchase of raw materials in inflationary times is one form of speculative behavior.

3.2. Improving Materials Management By Using Modern Technology

Such basic technology like mobile telephony or laptop is the most common available at the moment. Some other technologies such as internet, RFID (radio frequency identification), GIS (geographic information system), GPS (global positioning system), tracking technology are available in which have the capability of tracking materials. Use of IT has the capability for changing a cultural structure with an objective by reducing barriers between different functionality. IT also is a great opportunity for communication between different parties and different activities. Electronic data interchange (EDI) and Electronic funds transfer (EFT) are some other technologies in IT that enable a retailer to electronically do some functionality such as purchasing orders, paying invoices and processing credit checks. On site positioning and tracking technologies facilitate arranging for the arrival of materials just in time with right quality and quantity on construction job site while keeping the work in process inventory on the site to minimum the cost and time. Radio frequency base information and communication technologies, such as global positioning system (GPS), radio frequency identification (RFID) tags and Bluetooth have matured and become commercially available to potentially support resource positioning and tracking and automated data collection in construction. GPS technologies have the capability of tracking, managing and controlling earth moving and mining operations which occur in relatively open areas

3.3. Case studies

The subject of each of the G+2 projects analyzed is the execution of a 3-storey apartment building. Total area of building is 11105.85 Sq.ft. total estimated cost of project is 14167243RS. The building has, which walls are executed in the traditional, modernized technology. Works on all three investments, carried out in various locations (distance of about 20 km from each other), start on the same day and are carried out simultaneously.

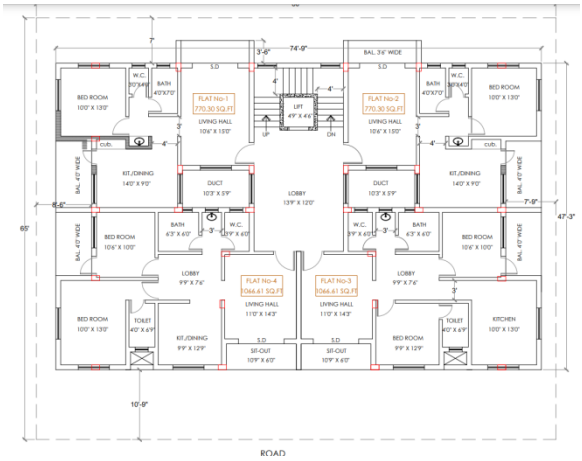

Figure 2 Plan of Apartment Building 1

The subject of each of the P+5 projects analyzed is the execution of apartment building. Total area of building is 22050 Sq.ft. total estimated cost of project is 39966289RS. The building has, which walls are executed in the traditional, modernized technology. Works on all three investments, carried out in various locations (distance of about 20 km from each other), start on the same day and are carried out simultaneously

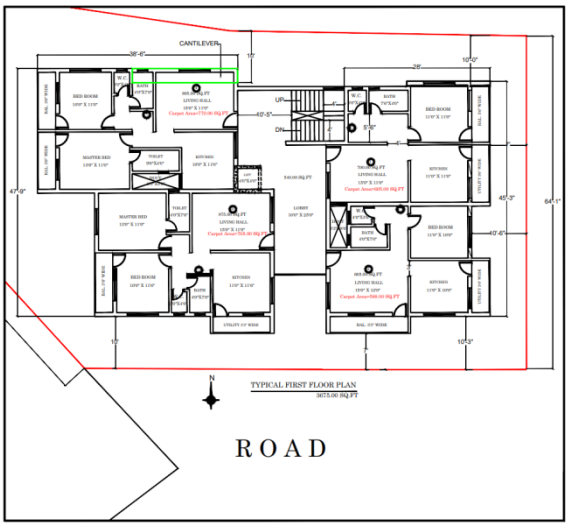

Figure 3 Plan of Apartment Building 2

V. RESULT AND DISCUSSION

5.1. Inventory Cost – Case 1

Table 1 Cost and Quantity of Cement Bags

Sr. No	Description	Quantity		Rate	No of order of material	Total Inventory Cost
		kg	Bags		S	TIC
1	Ground floor	89654	1793	336	4	638400.00
2	First floor	80497	1610	336	4	638400.00
3	Second floor	80497	1610	336	4	638400.00
	Total	**250648.3**	**5013**		**12**	**1915200**

Table 2 Cost and Quantity of Sand

Sr. No	Description	Quantity	Rate	No of order of material	Total Inventory Cost
		Cum		S	TIC
1	Ground floor	197	3560	2	700163.50
2	First floor	193	3560	2	688610.38
3	Second floor	188	3560	2	669280.00
	Total	**578**		**6**	**2058054**

Table 3 Cost and Quantity of Aggregate

Sr. No	Description	Quantity	Rate	No of order of material	Total Inventory Cost
		Cum		S	TIC
1	Ground floor	118	610	2	124337.5
2	First floor	78	610	1	62168.8
3	Second floor	78	610	1	62168.8
	Total	**274**		**4**	**248675**

Table 4 Cost and Quantity of Brickwork

Sr. No	Description	Quantity	No of Bricks	Rate	No of order of material	Total Inventory Cost
		Cum			S	TIC
1	Ground floor	104.3	52150	6	14	336000.0
2	First floor	104.3	52150	6	14	336000.0
3	Second floor	104.3	52150	6	14	336000.0
	Total	**312.9**	**156450**		**42**	**1008000.0**

5.2. Inventory Cost – Case 2

Table 5 Cost and Quantity of Cement Bags -2

Sr. No	Descriptions	Quantity		Rate	No of order of material	Total Inventory Cost
		kg	Bags		S	TIC
1	Parking floor	71520	1430	336	3	480613.37
2	First floor	85724	1714	336	4	576065.83
3	Second floor	85724	1714	336	4	576065.28
4	Third Floor	85724	1714	336	4	576065.28
5	Fourth Floor	85724	1714	336	4	576065.28
6	Fifth Floor	85724	1714	336	4	576065.28

	Total	**500139.9**	**10003**		**21**	**3360940**

Table 6 Cost and Quantity of Sand -2

Sr. No	Description	Quantity Cum	Rate	No of order of material S	Total inventory cost TIC
1	Parking floor	114	3560	1	404961.89
2	First floor	251	3560	2	892596.31
3	Second floor	251	3560	2	893560.00
4	Third Floor	251	3560	2	893560.00
5	Fourth Floor	251	3560	2	893560.00
6	Fifth Floor	251	3560	2	893560.00
	Total	**1368**		**13**	**4871798**

Table 7 Cost and Quantity of Aggregate -2

Sr. No	Description	Quantity Cum	Rate	No of order of material S	Total Inventory Cost TIC
1	Parking floor	123	610	1	74926.7
2	First floor	67	610	1	40895.2
3	Second floor	67	610	1	40870.0
4	Third Floor	67	610	1	40870.0
5	Fourth Floor	67	610	1	40870.0
6	Fifth Floor	67	610	1	40870.0
	Total	**458**		**4**	**279302**

Table 8 Cost and Quantity of Brickwork - 2

Sr. No	Description	Quantity Cum	No of Bricks	Rate	No of order of material S	Total Inventory Cost TIC
1	Parking floor	39.65	19825	6	5	118950.0
2	First floor	158.6	79300	6	20	475800.0
3	Second floor	158.6	79300	6	20	475800.0
4	Third Floor	158.6	79300	6	20	475800.0
5	Fourth Floor	158.6	79300	6	20	475800.0
6	Fifth Floor	158.6	79300	6	20	475800.0
	Total	**832.65**	**416325**		**104**	**2497950.0**

5.3. Economic Order Quantity

In this study, EOQ analysis is performed on case 1 for cement, bricks, and sand and aggregate. While performing EOQ analysis, the ordering cost and inventory carrying cost are calculated for each material with practical execution procedures for construction. The table concludes that the that the inventory costs of cement, sand, and aggregate are 1915200.0 RS, 1440518.40 RS, 185122.80 RS, and 1512000 RS, respectively.

Table 9 EOQ for Case 1

Material	Unit	Annual Demand (Units)	Cost Per Order	Carrying Cost Per Unit Per Year	EOQ	No Of Order	Average Inventory	Total Inventory Cost
		A	O	C	Q			
Cement	Bags	5013	1,684,356.28	84218	448	12	6	1,915,200.00
sand	cum	578	2,058,053.88	102903	152	4	2	1,440,518.40
Aggregate	cum	273.9217	167,092.25	8355	105	3	2	185,122.80
Brickwork	No	156450	938,700.00	46935	2502	63	32	1,512,000.00

Table 10 Frequency of Ordering Of Cement Bags

Year	Month	No Of Order	Total Inventory Cost
2023	Jan to Jun	4	638400
	July to Dec	4	638400
2024	Jan to Jun	4	638400
Total cost			**1915200**

Table 11 Frequency of Ordering Of Sand

Year	month	No of Order	Total Inventory Cost
2023	Jan to Jun	2	7202592
	July to Dec	1	3601296
2024	Jan to Jun	1	3601296
Total cost			**14405184**

Table 12 Frequency of Ordering Of Aggregate

Year	Month	No Of Order	Total Inventory Cost
2023	Jan to Jun	2	123,415.20
	July to Dec	1	61,707.60
Total cost			**185,122.80**

Table 13 Frequency of Ordering Of Brickwork

Year	Month	No Of Order	Total Inventory Cost
2023	Jan	4	96000
	Feb	4	96000
	Mar	4	96000
	Apr	4	96000
	May	4	96000
	Jun	4	96000
	Jul	4	96000
	Aug	4	96000
	Sep	4	96000
	Oct	4	96000
	Nov	4	96000
	Dec	4	96000
2024	Jan	3	72000
	Feb	3	72000

	Mar	3	72000
	Apr	3	72000
	May	3	72000
Total Cost			**1512000**

In this study, EOQ analysis is performed on case 2 for cement, bricks, and sand and aggregate. While performing EOQ analysis, the ordering cost and inventory carrying cost are calculated for each material with practical execution procedures for construction. The table concludes that the inventory costs of cement, sand, and aggregate are 2553600RS, 2160777.60 RS, 246830.40 RS, and 2472000RS, respectively.

Table 14 EOQ for Case 2

Material	**Unit**	**Annual Demand (Units)**	**Cost Per Order**	**Carrying Cost Per Unit Per Year**	**EOQ**	**No Of Order**	**Average Inventory**	**Total Inventory Cost**
		A	O	C	Q			
Cement	Bags	10003	3,360,940.31	168047	633	16	8	2,553,600.00
sand	cum	1368	4,871,798.20	243590	234	6	3	2,160,777.60
Aggregate	cum	457.8719	279,301.87	13965	135	4	2	246,830.40
Brickwork	No	416325	2,497,950.00	124898	4081	103	52	2,472,000.00

Table 15 Frequency of Ordering Of Cement Bags

Year	**Month**	**No of Order**	**Total Inventory Cost**
2023	Jan to Jun	6	957600
	July to Dec	5	798000
2024	Jan to Jun	5	798000
Total cost			**2553600**

Table 16 Frequency of Ordering Of Sand

Year	**Month**	**No Of Order**	**Total Inventory Cost**
2023	Jan to Jun	3	10803888
	July to Dec	1	3601296
2024	Jan to Jun	2	7202592
Total cost			**21607776**

Table 17 Frequency of Ordering Of Aggregate

Year	**month**	**No of Order**	**Total Inventory Cost**
2023	Jan to Jun	2	123,415.20
	July to Dec	2	123,415.20
Total cost			**246,830.40**

Table 18 Frequency of Ordering Of Brickwork

Year	**Month**	**No Of Order**	**Total Inventory Cost**
2023	Jan	6	144000
	Feb	6	144000
	Mar	6	144000
	Apr	6	144000
	May	6	144000
	Jun	6	144000
	Jul	6	144000
	Aug	6	144000

	Sep	6	144000
	Oct	6	144000
	Nov	6	144000
	Dec	6	144000
2024	Jan	6	144000
	Feb	6	144000
	Mar	6	144000
	Apr	6	144000
	May	6	144000
Total cost			**2448000**

5.4. Comparison of Inventory Cost in Cost Saving

Table 19 Comparison of Inventory Cost -1

Material	Quantity	Inventory Cost	Inventory Cost BY EOQ	Cost Saving	% Diff
Cement	10003	1915200	1915200	0	0.00
Sand	578.105	2058053.9	1440518.4	617535	30.01
Aggregate	273.9217	248675.04	185122.8	63552.2	25.56
Brickwork	156450	1008000.0	1512000	504000.0	50.00
Total		**5229928.9**	**5052841.2**		

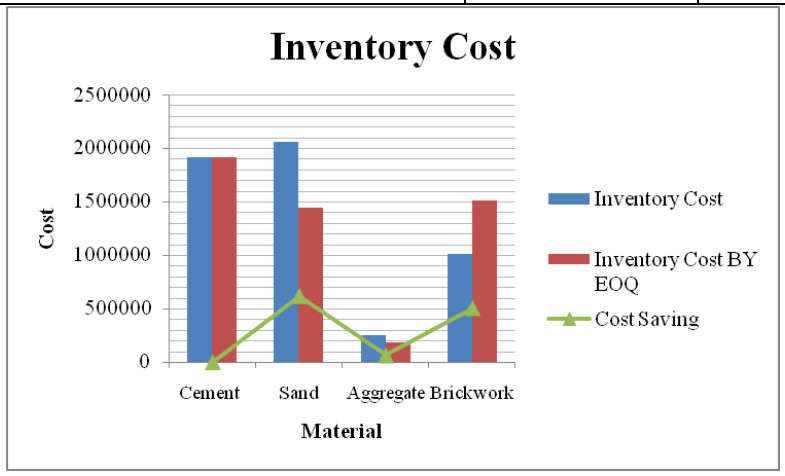

Figure 4 Comparison Of Inventory Cost For Case 1

Figure shows the comparison of inventory costs for cases 1. The results conclude that the total material inventory cost is 5229928.9RS and inventory by EOQ is 5052841.2RS. The highest number of bricks cost is saved by 50% and the minimum 25.56% cost is saved by aggregate when applying EOQ inventory control techniques.

Table 20 Comparison of Inventory Cost -2

Material	Quantity	Inventory Cost	Inventory Cost BY EOQ	Cost Saving	% Diff
Cement	10003	3360940.3	2553600	807340	24.02
Sand	1368.483	4871798.2	2160777.6	2711021	55.65
Aggregate	457.8719	279301.87	246830.4	32471.5	11.63
Brickwork	416325	2497950	2472000	25950	1.04
Total		**11009990**	**7433208**		

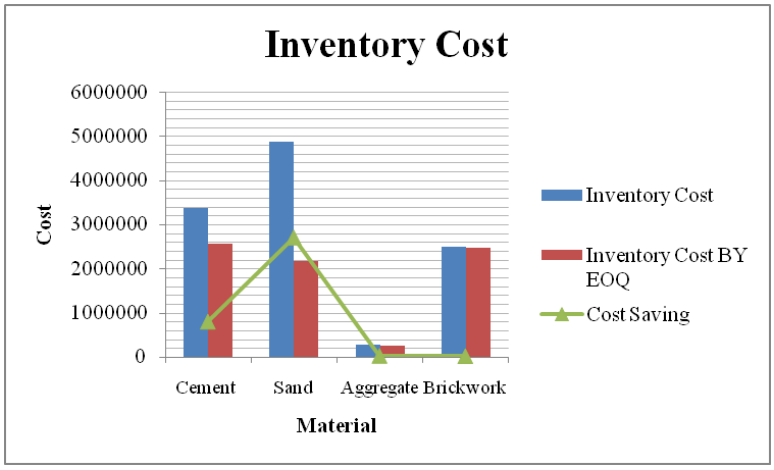

Figure 5 Comparison Of Inventory Cost For Case 2

Figure shows the comparison of inventory costs for cases 2. The results conclude that the total material inventory cost is 11009990RS and inventory cost by EOQ is 7433208RS. When applied to the economic order quantity method, and the cost is saved in inventory. The highest sand material cost is saved by 55.65%, and the minimum number of bricks is saved by 1.45%.

5.5. Comparison of Estimated & Inventory Cost

Table 21 Comparison of Inventory Cost -1

Material	Estimated Cost	Cost dff. in estimate to inventory	Inventory Cost	% diff between estimated and inventory cost	Inventory Cost BY EOQ	Cost dff in estimate to EOQ	% diff between estimated and EOQ cost
Cement	2803797	735381.4	2068416	73.77	2068416	735381.398	73.77
Sand	2803797	581098.8	2222698.2	79.27	1555760	1248037.13	55.49
Aggregate	2803797	2535228	268569.04	9.58	199933	2603864.38	7.13
Brickwork	1690130	601489.8	1088640	64.41	1632960	57169.8	96.62

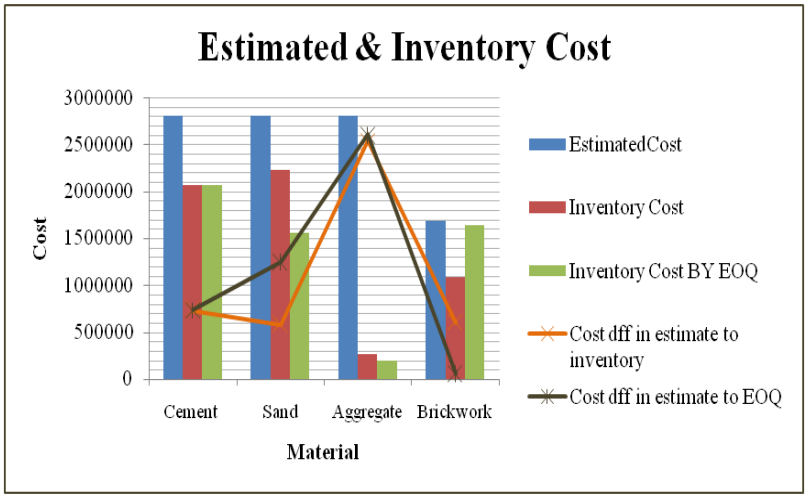

Figure 6 Comparison of Estimated & Inventory Cost For Case 1

Figure shows the comparison of estimated &inventory costs for cases 1. The results conclude that highest percentage difference in estimated and inventory cost is 79.27 for concrete and brickwork is 64.41. Similarly highest percentage difference in estimated and EOQ cost is 73.77 and brickwork is 96.62

Table 22 Comparison of Inventory Cost -2

Material	Estimated Cost	Cost diff in estimate to inventory	Inventory Cost	% diff between estimated and inventory cost	Inventory Cost By EOQ	Cost diff in estimate to EOQ	% diff between estimated and EOQ cost
Cement	5780307	2150491.6	3629815.5	62.80	2757888	3022419.1	47.71
Sand	5780307	518764.94	5261542.1	91.03	2333639.81	3446667.19	40.37
Aggregate	5780307	5478661	301646.02	5.22	266576.832	5513730.17	4.61
Brickwork	5138640	2440854	2697786	52.50	2669760	2468880	51.95

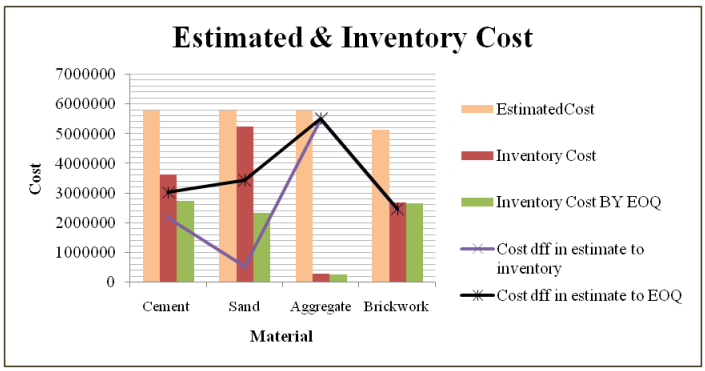

Figure 7 Comparison of Estimated & Inventory Cost For Case 2

Figure shows the comparison of estimated & inventory costs for cases 2. The results conclude that highest percentage difference in estimated and inventory cost is 91.03 for concrete and brickwork is 52.50 Similarly highest percentage difference in estimated and EOQ cost is 47.71 and brickwork is 51.95

VI. CONCLUSION

In our study, consider two apartment building estimates calculated for material management. In construction, mostly cement, sand, aggregate, and brickwork are the main required materials, and we are mostly finding delays in the delivery of these materials. So we have maintained the quality and quantity of material by applying inventory techniques as well as cost-saving purchasing of material.

- **Inventory Cost Without Applying EOQ**
  - ❖ Cement - The result concludes that the cost of 5013 bags is 1915200 RS, and a total 12 orders of cement bags were ordered in case study 1 for the (G+2) building. Similarly, 10003 bags are 3360940RS, and a total 21 orders of cement bags are ordered in case study 2, which are a (P+5) building.
  - ❖ Sand - The study concludes that the cost of 578 cum sand is 2058054RS, with a total of 6 orders of sand ordered in case study 1 for the (G+2) building. Similarly, 1368 cm of sand is 4871798RS, and a total 13 orders of sand are ordered in case study 2, which is a (P+5) building.
  - ❖ Aggregate - The study concludes that the cost of 274 cum aggregates is 248675RS, and a total of 6 orders of sand were ordered in case study 1 (G+2) building. Similarly, 458cum aggregate is 279302RS, and a total of 4 orders of aggregate are ordered in case study 2, which is a (P+5) building.
  - ❖ Brickwork - The study concludes that the cost of 156450 no. of bricks is 1008000.0RS, and a total of 42 orders of bricks were ordered in case study 1 (G+2) building. Similarly, 416325 no of bricks is 2497950RS, and a total of 104 orders of brick are ordered in case study 2, which is a (P+5) building.
- **Inventory Cost With Applying EOQ**
  - ❖ Cement - The result concludes that the cost of 5013 bags is 1915200 RS, and a total 12 orders of cement bags were ordered in case study 1 for the (G+2) building. Similarly, 10003 bags are 2553600.0RS, and a total 16 orders of cement bags are ordered in case study 2, which are a (P+5) building.
  - ❖ Sand - The study concludes that the cost of 578 cum sand is 1440518.40RS, with a total of 4 orders of sand ordered in case study 1 for the (G+2) building. Similarly, 1368 cm of sand is 2160777.60RS, and a total 6 orders of sand are ordered in case study 2, which is a (P+5) building.
  - ❖ Aggregate - The study concludes that the cost of 274 cum aggregates is 185122.80RS, and a total of 3 orders of sand were ordered in case study 1 (G+2) building. Similarly, 458cum aggregate is 246830.40RS, and a total of 4 orders of aggregate are ordered in case study 2, which is a (P+5) building.
  - ❖ Brickwork - The study concludes that the cost of 156450 no. of bricks is 1512000RS, and a total of 63 orders of bricks were ordered in case study 1 (G+2) building. Similarly, 416325 no of bricks is 2472000.0RS, and a total of 103 orders of brick are ordered in case study 2, which is a (P+5) building.
- **Comparison of Cost saving**
  - ❖ In case 1, the total inventory cost of cement, sand, aggregate, and brick is 5229928.9 RS, and the EOQ inventory cost is 5052841. 2RS Result concludes 617535RS, 63552.2RS, and 504000 cost savings by applying inventory control techniques to sand aggregate and brick material, which are 30.01%, 25.56%, and 50%, respectively.
  - ❖ In case 2, the total inventory cost of cement, sand, aggregate, and brick is 11009990 RS, and the EOQ inventory cost is 7433208RS Result concludes 807340RS, 2711021RS, 32471.5RS and 25950RS cost savings by applying inventory control techniques to cement, sand, aggregate and brick material,

which are 24.02%, 55.65%, 11.63%and 1.04%, respectively.

- The Total cost of inventory after adoption of EOQ analysis is less than without adopting EOQ.

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