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Issues in Material Management using Gap Analysis

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ABSTRACT
This study explores the various factors responsible for material cost overrun and the corresponding gap in the estimated and actual material usage. Construction projects in India are often undertaken by Small to Medium sized Enterprises (SMEs), and are heavily susceptible to an increase in cost from the estimated value leading to the SMEs not being able to arrange for the required additional funds.

KEYWORDS - *Material Management, Construction, Cost overrun , Gap Analysis, SME Projects.*

INTRODUCTION

Background

The construction sector in India is comprised largely of Small and Medium sized Enterprises (SMEs). As opposed to large companies which have the capacity and capability to use sophisticated information and management technology to supervise and manage a construction project, SMEs are generally poorly equipped to implement such systems. Thus, improvements in labour and material efficiency are generally difficult to achieve.

Since SME's operate on low cash flows, the materials are generally ordered at infrequent and irregular intervals. Without proper management and site oversight, offloading, storage and tracking of materials is highly inefficient. The cost represented by materials fluctuates and may comprise between 60% - 70% of the total project cost and sometimes more [1],[2]. Hence, any ways to reduce wastage and improve productivity will have major benefits to cost and time.

Any substantial increase in the estimated project costs—like those resulting from poor management of construction materials—is difficult for the developer to adjust for. This sometimes leads to projects being stalled for years, and in extreme cases, abandoned. Thus, proper management of construction materials becomes a highly effective strategy to substantially improve feasibility and reduce costs in a construction project.

Aim of the Study

The aim of this study was to recognise the various factors involved in management and handling of construction materials, and to study the factors responsible for the increase in the actual material usage as compared to the estimated usage.

Methodology

The scope of the study was to understand the procurement methods, logistics, storage, usage, and wastage of materials during the construction phase of the project. The materials selected for study were limited to Concrete (Cement, Sand, and Aggregate) and Steel, since they contribute primarily to the material costs in Reinforced Cement Concrete (RCC) Construction.

For comparison of estimated material usage and actual material usage, Gap analysis was done using S-curves. Construction protocols and actual on-site conditions were recorded and analysed using detailed questionnaires.

MATERIAL MANAGEMENT

Definition

Material management is defined as planning, identification, procuring, storage, receiving and distribution of materials. Material management functions include "material requirement planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory and material distribution" [3].

Many factors contribute to poor material management in construction projects. Factors such as waste, transport difficulties, improper handling on site, misuse of the specifications, lack of proper work plan, inappropriate material delivery, and excessive paperwork, all adversely effect on material management [4]. It has been an issue of concern in the construction industry; 40% of the time lost on site can be attributed to bad management, wastage of material, lack of materials when needed, poor identification of materials and inadequate storage [5].

Impact of Material Management
Effective material management has a positive impact on

- Time optimization,
- Cost saving,
- Quality maximization,
- Productivity improvement, and
- Waste minimization

Ineffective material management, on the other hand, has a negative impact on project performance. Delays in project completion time due to untimely unavailability can cause increase in expenses and thus has an adverse impact on the potential feasibility of the project. Poor planning and procurement, as well as mishandling of materials due to poor material management can lead to increased wastage and thus, an increase in cost.

Poor material management can also affect the quality of the required project; materials not stored properly or used in a timely fashion decline in quality. Problems in material management also leads to a decline in labour efficiency, since they cannot work as productively as they can. Thus, we see that the impact of material management is cumulative in nature.

Importance in SMEs and SRA projects

An SME is project driven and is always battling to reduce costs and save money. They tend to win their work on low bid price, rather than superior technology. These bids are based upon resource estimating using knowledge and experience from previous projects, and are often their only guideline for project cost going into the project. Increased costs in the middle of construction can lead to adverse effects on their cash flow; This cash flow is crucial to pay suppliers on time to ensure future materials supply.

Material management, a crucial part in any construction project has more sensitivity in this case due to the proximity of the site to the residents, more vulnerability due to the anti-social elements in the surrounding slum areas etc. It is essential therefore, that an improved material management system be adopted so that the project can be completed efficiently, be cost effective and complete on schedule.

CASE STUDIES

Three case studies were selected which were from Mumbai. The Phase 1 of all the projects has been completed in all the case studies, and the rest is ongoing.

Table 1 - Details of selected case studies

Description	Case Study 1	Case Study 2	Case Study 3
Total plot area in sqm	16,184.76	12674.34	3152.94
Ground coverage area in sqm	1980.00	1480.00	895.00
Height of buildings (mt)	23.8	49.9	23.8
Constructed area (sqm)	8156.27	13001.40	5940.50
Type of construction	RCC framework Brick partitions	RCC framework Brick partitions	RCC framework Brick partitions
Construction undertaken by	Developer (SME)	Developer (SME)	Developer (SME)
Estimated Construction Cost estimate (Cr)	9.67	13.1	7.92
Estimated Construction Period Phase I	26 months	45 months	24 months
Total Construction Cost Phase I (Cr)	11.65	16.8	9.78
Total Construction Period Phase I	42 months	78 months	35 months
Proposed FSI	Phase I - 2.5, II&III - 3.0	Phase I, II, III-3.0	Phase I - 2.5, II&III - 3.0

Data
The below S curve analysis presents the gap between the estimated and actual quantity with respect to time, for all the materials in each case study.

Cement Consumption

Table 2 – Cement Consumption

Description	Case Study 1	Case Study 2	Case Study 3
Design Mix	M20	M25	M20
Estimated Qty (bags)	43000	70000	21500
Total Qty Used (bags)	52180	87935	25700
Deviation in Cement Qty	21.2%	25.6%	19.3%

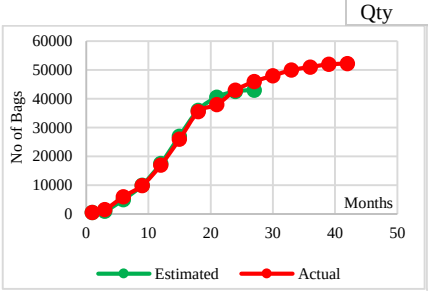

Fig 1.1 Case Study 1

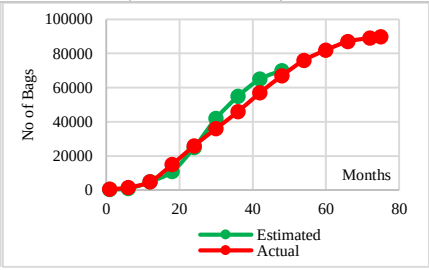

Fig 1.2 Case Study 2

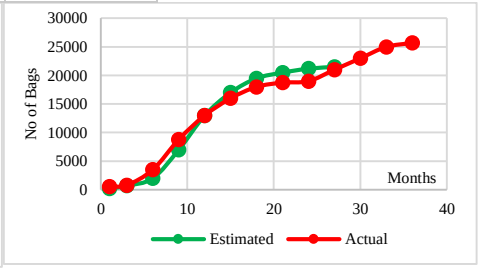

Fig 1.3 Case Study 3

Sand Consumption

Table 3 – Sand Consumption

Description	Case Study 1	Case Study 2	Case Study 3
Estimated Qty (ton)	1900	3920	940
Total Qty Used (ton)	2296	4925	1106
Deviation in Sand quantity	20.6%	26.7%	15.6%

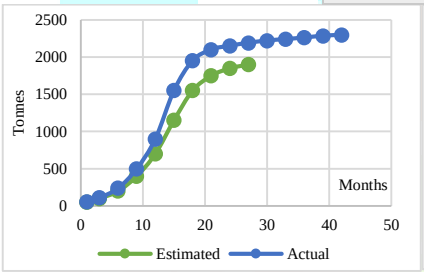

Fig 2.1 Case Study 1

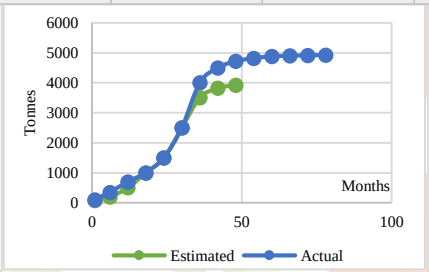

Fig 2.2 Case Study 2

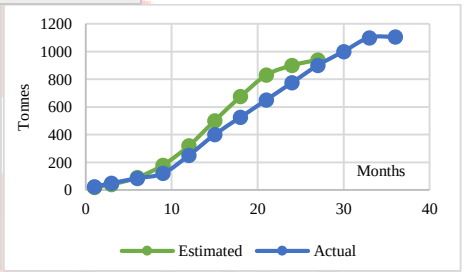

Fig 2.3 Case Study 3

Aggregate Consumption

Table 4 – Aggregate Consumption

Description	Case Study 1	Case Study 2	Case Study 3
Estimated Qty (ton)	3800	7840	1880
Total Qty Used (ton)	4592	9850	2212
Deviation in Aggregate Qty	20.7%	25.6%	15.6%

Aggregate Consumption

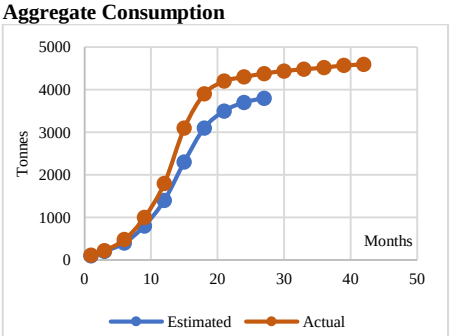

Fig 3.1 Case Study 1

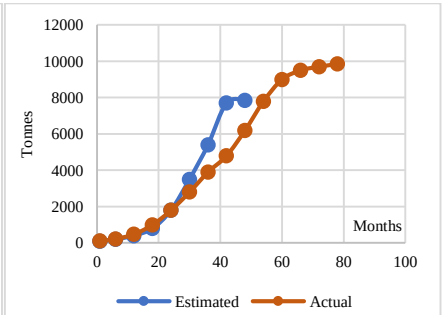

Fig 3.2 Case Study 2

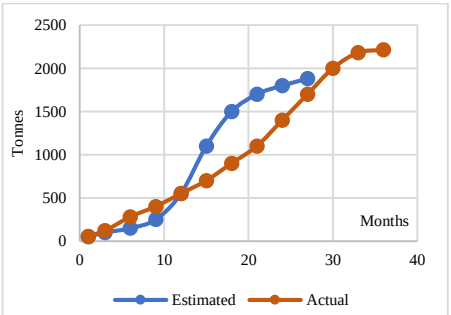

Fig 3.3 Case Study 3

Steel Consumption

Table 5 – Steel Consumption

Description	Case Study 1	Case Study 2	Case Study 3
Estimated Qty (ton)	650	780	320
Total Qty Used (ton)	802	957	406
Deviation in Steel quantity	24.6%	22.3%	23.7%

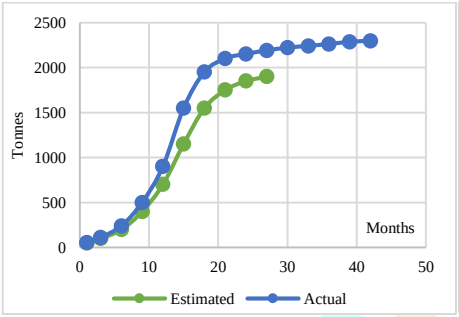

Fig 4.1 Case Study 1

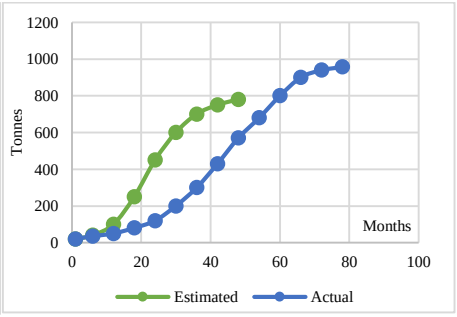

Fig 4.5 Case Study 2

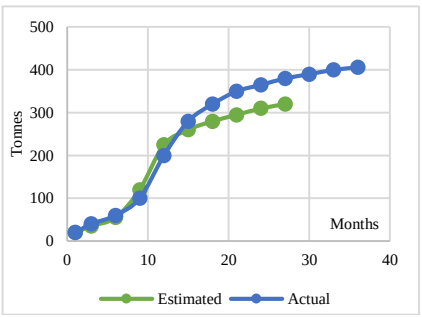

Fig 4.3 Case Study 3

Gap Analysis

From the selected case studies, data was obtained in the form of usage statistics and questionnaires to the personnel responsible for material management. The gap in material usage and its impact on the project cost is summarised in Table 6. The primary factors responsible for these variations were identified as wastage and Bill Of Quantity (BOQ) changes.

Construction projects are prone to numerous changes in the plan specifications. However, the BOQ prepared before commencement of the project does not undergo periodic updating in spite of any changes in the plan.

The losses due to wastage were found to be approximately 3-5% of the material cost. The most common reasons were material shortage and subsequent overordering. This, coupled with late ordering and delay in delivery is indicative of a lack of organization and planning.

Table 6 - Actual material usage and cost overrun

S. No	Description	Case Study 1	Case Study 2	Case Study 3
1	Design Mix	M20	M25	M20
2	Total Cement Used (bags)	52180	87935	25700
3	Deviation in Cement quantity	21.2%	25.6%	19.3%
4	Total Sand Used in ton	2296	4925	1106
5	Deviation in Sand quantity	20.6%	26.7%	15.6%
6	Total Coarse Aggregate Used in ton	4592	9850	2212
7	Deviation in Aggregate quantity	20.7%	25.6%	15.6%
8	Total Steel Used ton	802	957.3	406
9	Deviation in Steel quantity	24.6%	22.3%	23.7%
10	Estimated Construction Cost(Cr)	9.67	13.1	7.92
11	Final Construction Cost actual (Cr)	11.65	16.8	9.78
12	Estimated Const. cost deviation	10% -12%	12-15%	10%
13	Actual Construction Cost Deviation	17%	22%	19%
14	Impact of the Increased Cost	Delay in completing project.	Profit margin reduced drastically	Delay in completing project.
15	Impact due to project delay – projected loss	10% of project cost	15 % of project cost	10% of project cost

The factors responsible for the material mismanagement can be summarised as shown in Figure 5

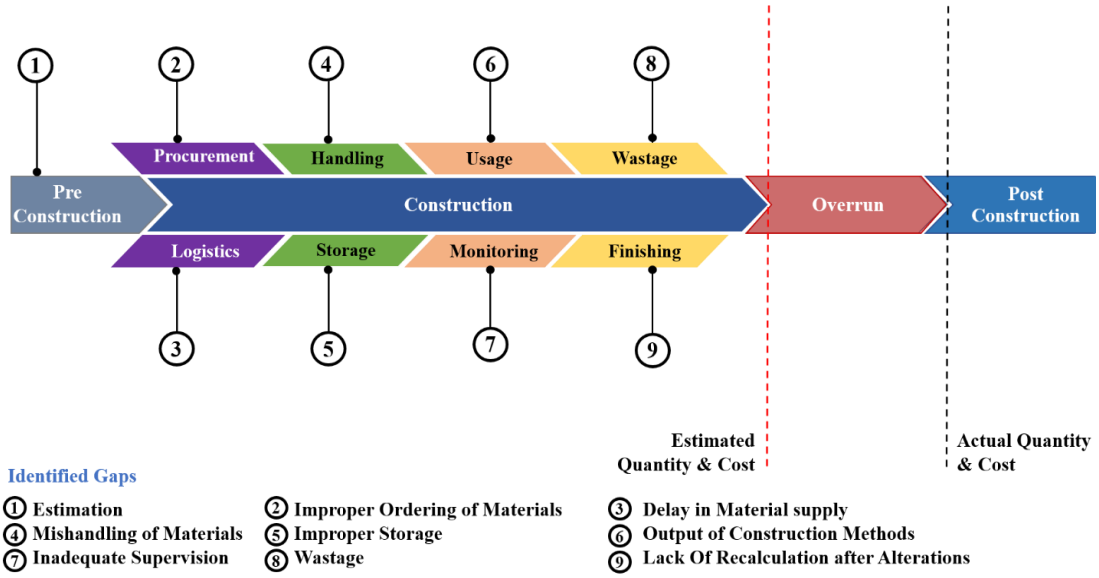

Figure 5 - Identified Gaps in Material Management

1. Estimation – The lack of a periodic update of the material quantity and cost lead to error in the initial estimate of the project. Alterations due to site conditions, often significant are ignored, and disturbs any planned material management.
2. Improper Ordering of Materials – Materials are not ordered in a timely fashion, nor are management techniques like Just-in-Time ordering and Economic Order Quantity (EOQ) followed. This leads to overordering of materials and subsequent wastage.
3. Delay in Material Supply
4. Mishandling of Materials – There is a general lack of discipline and set protocols for the different activities being undertaken during the construction phase. The lack of discipline towards the usage and handling of the materials can be attributed to the use of labour contract, as efficient use of materials is not a priority for the contractor.
5. Improper Storage – Storage facilities found were severely lacking. The scarcity of space, the nature of the location, and the surrounding antisocial elements present in the slums make the safe storage of materials a difficult task.
6. Output of Construction Methods – Inefficient techniques and technologies like manual bar bending machines and on-site concrete mixers lead to about 8-10% of material wastage which is often not accounted for in original estimates.
7. Inadequate Supervision - Adequate supervision by qualified professionals on the site is found to be sorely needed due to the lack of proper protocols and communication. Delays in performing inspections and testing lead to rework required on site, and thus increase in material and cost.
8. Wastage
9. Lack of Recalculation – Since due to the nature of typical construction projects in India it is impossible to to do in-depth testing prior to excavation, there is a high possibility that an unexpected feature of the site can substantially affect initial estimate. In spite of easy and ready availability of Management Information Systems (MIS) and Building Information Management (BIM) software, there is no attempt to use these tools for the same, and the recalculation is not done with due diligence.

CONCLUSION

Material management is important to the success of a construction project, since material accounts for the majority of the construction costs. Construction projects mainly undertaken by SMEs are thus highly susceptible to the adverse effects of poor material management. By looking at selected case studies of such projects, the primary factors of such mismanagement were identified as seen in Figure 1.

It is possible for an SME to tackle such mismanagement using suitable combinations of established management techniques. Periodic update of estimation can be done using BIM software. EOQ and JIT can be used to improve efficiency in procurement and logistics. ABC analysis of material management can be applied to the required materials in order to allocate storage and prioritize handling. Newer technologies can like Pre-Cut steel bars and Ready-Mix Concrete (RMC) can be used to reduce wastage. MIS software can be used to track and monitor progress of the project and accurately communicate information.

Thus, it is important to understand the impact that material management has on a project. The feasibility and timely completion of the project, which are primary concerns for a developer, largely depend on it.

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