Material Focused Control During A Construction Project

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Abstract
The construction industry, is mostly concerned with one – of – a – kind projects. This, naturally, creates difficulties for effective management control. Nevertheless, production costs need to be monitored and controlled, if the anticipated level of profit is to be realized. One of the most difficult things to control is the variance associated with materials. All supplies and materials add to the cost parameter of the project. Thus, greater attention to controlling the materials may pay significant dividends in the form of increased profit. This paper deals with monitoring and controlling the cost of materials during project execution. Reference and review will be made to the special characteristics of the construction industry as far as the cost parameters is concerned, during project development. Then, definition of materials and its cost elements and characteristics will be given. The proposed approach for controlling this cost category is based on a spreadsheet application. The component spreadsheets are identified and analyzed and their use is explained. Special consideration will be given to the description of the information content of each spreadsheet. These spreadsheets integrate the cost parameters with time and project advancement, so that the project manager could acquire an objective view of the cost deployment.

Keywords
Cost Control, Materials, Spreadsheets, Construction Industry.

1. Introduction

There are many factors that have an impact on the direct cost, such as materials to be incorporated (Popescu *et al*., 2001). Materials expenditure represents a major proportion of contract value. Therefore, the control of purchasing, scheduling, delivery and handling of materials on site is an essential part of the control process (Cooke and Williams, 2004). Materials have two components: quantity and cost (Popescu *et al*., 2001). In the case of materials, a distinction can be made between the variances of price and the changes in the level of their use due to the efficiency or otherwise of the activity (Pilcher, 1994).

One of the most difficult things to control is material variance. All supplies and materials add to the cost parameter of the project. Materials usually account for between one-third and one-half of the cost of a building project. This is largely due to the nature of the construction sites. Furthermore, there is growing evidence that losses due to materials are often significantly higher than those due to other causes. Thus, greater attention to materials control may pay significant dividends in the form of increased profit.

The problems related to materials during construction can be summarized as follows:

- Material is delivered daily at the same time that tens to hundreds of workers must come together to complete their assignments. As construction proceeds, the site becomes congested.
- Despite the fact that the estimate and plans were made with a large factor of safety in each and every task, many activities consume more than their estimated time and cost.
- During construction, frequent changes are introduced to the scope of work, thus causing a lot of work disruption and cost overrun.
- Dealing with suppliers and subcontractors may not be easy (Hegazy, 2002).

In this paper, the appropriate set of modules necessary to facilitate monitoring and controlling of the cost factor in a reliable and realistic manner is identified. These modules are defined and their content is presented and analyzed. They are based on MS Excel and VBA (Visual Basic for Applications) and provide useful information for all aspects of material cost occurring during the construction of a project. Finally, future work on improving the proposed system is presented.

2. Cost Control

In the construction sense, costs are planned, they may be refined as the work proceeds, and, if they are not in accordance with the plan, the reasons can be determined. Such reasons may include poor management, and one of the chief reasons for cost control is to detect such mismanagement (Royer, 1974).

Cost control has been defined as the regulation by executive actions of the cost of carrying out various activities. In a dynamic environment, however, one should have the pragmatic view that the ultimate objective of a cost control system is to produce the least costly product. Within this overall task, project cost management is concerned with the allocation of resources, to the individual project activities involving continuous monitoring of the final cost of these activities and implementing control action, where necessary, in the form of decisions either to limit their scope or to re-allocate resources amongst them (Denmead, 1980). How efficient, a cost control system is, can be judged by how quickly it identifies deviations and initiates proper actions to be taken (Nandi and Dutta, 1988).

To control spiraling costs, a suitable platform must be established so, to serve as a reliable control framework. This is usually the budget estimate. Such an estimate must, however, be carefully analyzed to serve as a mainstay of a cost control program. It is important to locate weak points in the estimate from the very outset of design long before construction begins. Projected contingency and cost escalation provisions also deserve a second look once the project is a definite possibility (Mendel, 1976).

The basic elements of a cost control system in project environment should comprise a project plan, continuous monitoring system, a reporting system that identifies deviations, and timely actions to take advantage of beneficial trends and to correct deviation (Nandi and Dutta, 1988).

The basis for any good cost control program is a good cost monitoring system, based on prior records of project costs, or budget estimate (Mendel, 1976).

The objectives of a control system are:

- To draw immediate attention to any activity that is proving to be uneconomic to the contractor, in order that corrective action can be taken to keep cost within acceptable bounds
- To analyze the construction progress in every period and determine how well things are proceeding according to the plan
- To develop actual production rates of labor and equipment and actual percentages of material wastage to feedback estimating of future works (Hegazy, 2002).

A cost tracking and reporting system that can be updated with any changes to the budget (both in terms of quantities and costs), with actual costs as they are committed or expended and with the latest estimation at completion (EAC) should also be used. Project Controls, in conjunction with the Project Manager and Procurement should develop the methodology for incorporating the commitment information and changes to quantities and costs into the company or customer cost tracking and reporting system (Richard and Westney, 1997).

3. Principles to be Addresed by the Proposed Contractor's Project Cost Control System

There can be differences of opinion as to whether the scheduling process and the cost control process should be controlled by an integrated reporting system (Pilcher, 1994). In this study, the proposed cost control system is not integrated with a scheduling system. The proposed application uses scheduling instances, which it acquires from external standalone applications. It is in the future research's intentions to incorporate in the system a scheduling module.

In order for a cost control system to be used effectively and easily it is necessary to be able to identify with accuracy, and to record the resources clearly identified against the activities or operations for which they have been used. If this is to be done, then an appropriate coding is required in order to identify the various attributes of a particular section of the work. Further, a cost control system must exhibit the characteristic of relevance. All the information that is presented to a manager must be entirely relevant to his responsibility and his position in an organizational hierarchy. It must be sufficient for him to make managerial decisions readily and to apply his judgment in the process. It must have the appropriate material content and the timing of its arrival in the manager's hands must be exact. The cost control system must also have the characteristic of reliability. There must be neither errors in the input and the output nor as a result of the processing of data before presenting it as information (Pilcher, 1994).

In setting up a cost control system, the first action must be to identify elements of cost. These must reflect the way in which the work is broken down into operations of activities and care must be taken to see that the level of breakdown provides sufficient detail for good control (Pilcher, 1994). The Work Breakdown Structure (WBS), is typically a cascading outline of scope that lists the project at the topmost level of the structure and then subdivides into functional systems, physical areas, sequential phases, or other major subdivisions (Richard and Westney, 1997).

On the other hand, care must be taken to see that the breakdown of work (and hence cost) is not into such small elements where control becomes unjustified and leads to erratic results. The budget upon which the cost control system will be based will have, in most instances, to spring from the estimate of cost for the work whether it is prepared for a tender or in some other way. If the estimate is closely followed and it is in the usual form of such estimates, then control in the field will provide feedback which will be recognized as being useful to the estimating process (Pilcher, 1994).

There is little point in breaking work down for cost control purposes into elements that cannot be recognized by constructors in the field. The breakdown into elements will preferably follow a pattern which is reasonably standard throughout a particular company so that comparisons can be made between

the unit cost of the various items which are placed in similar situations on a number of different jobs. This also has the advantage that usage of the system will create familiarity with this type of breakdown (Pilcher, 1994).

All extraordinary items must be noted in feedback so that the estimating process can be updated and be as reliable as possible. When work is in progress, costs must be collected in the field and apportioned to the particular activities which form the elements of the work and against which comparisons will be made. It is critical to assign these costs to the correct cost element. Similarly with allocating labour costs to cost elements, it is necessary to undertake the same process with regard to materials so that productivity data can be maintained. It is particularly important that scrap and waste is noted where the use of materials is concerned (Pilcher, 1994).

4. Framework of the Proposed System

4.1 Design Characteristics - Parameters

It is essential to design every spreadsheet in a strict logical order so that the user will be directed to filling all the necessary cells with the appropriate data. Wrong placement of column and rows or false order may confuse an amateur user. This situation can result to mistakes, time losses, rework and as a result minimize the productivity rates, performance and the resulting friendliness of the application.

The importance of proper design of the human computer interface becomes more apparent in the cases of extremely critical functions. Complex systems, which automate a great number of functions require a well designed interface. The introduction of new methods for automation and new applications provides new means of existence and a new framework of interaction which did not previously exist. This new framework instead of making people's tasks easier, usually causes more difficulties since the routine functions are automated but the difficult decisions are left to the user to deal with (Avouris, 2000).

It is very important to maintain a standard terminology throughout the various spreadsheets that belong to a specific workbook but also among different workbooks too. Application of these uniform naming standards can ease the task of comparing the costs occurring in different projects. This way, knowledge gained from previous projects and historical cost data could be applicable for comparisons and for predictions in new projects. This data re-use and application can be possible between different construction companies as well. It becomes obvious that there is a need for a standard naming policy. A solution to this problem could be the application of "UNIFORMAT" naming procedures (Aretoulis *et al*., 2003), or a combination of Categorical Breakdowns (e.g. Masterformat Subdivisions) and a proper code of accounts which can be identical to the lowest level of the WBS (Richard and Westney, 1997).

The conceptual structure of an integrated cost control system is available in Figure 1. All the necessary elements, for a construction project cost control system, are presented and the "material control module" is highlighted.

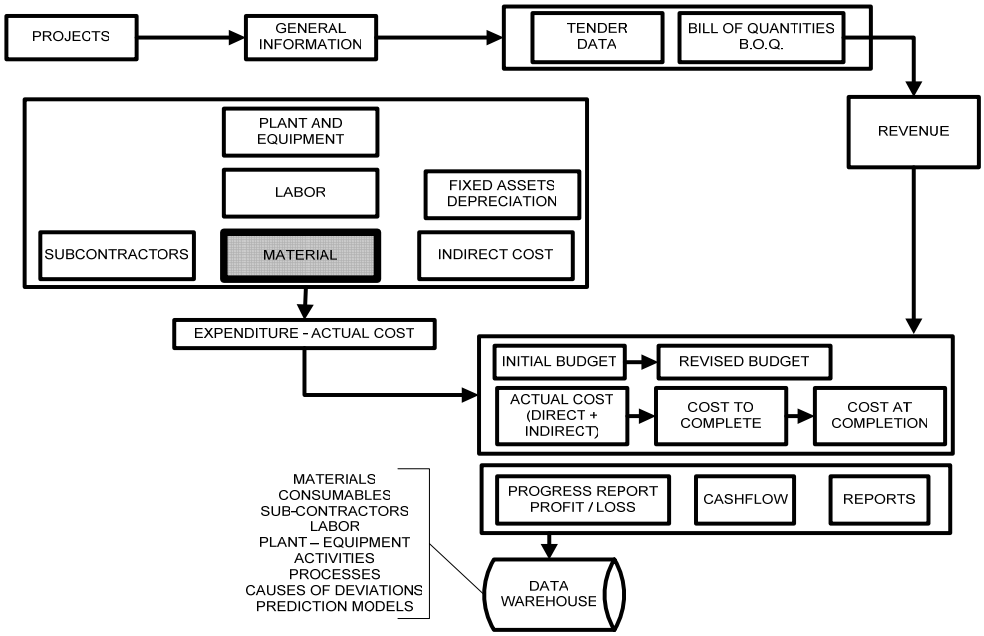

Figure 1: Integrated Cost Control System

Figure 2, essentially focuses in the material cost control module, and provides a framework for its function. All the parameters involved in the material cost control system are highlighted:

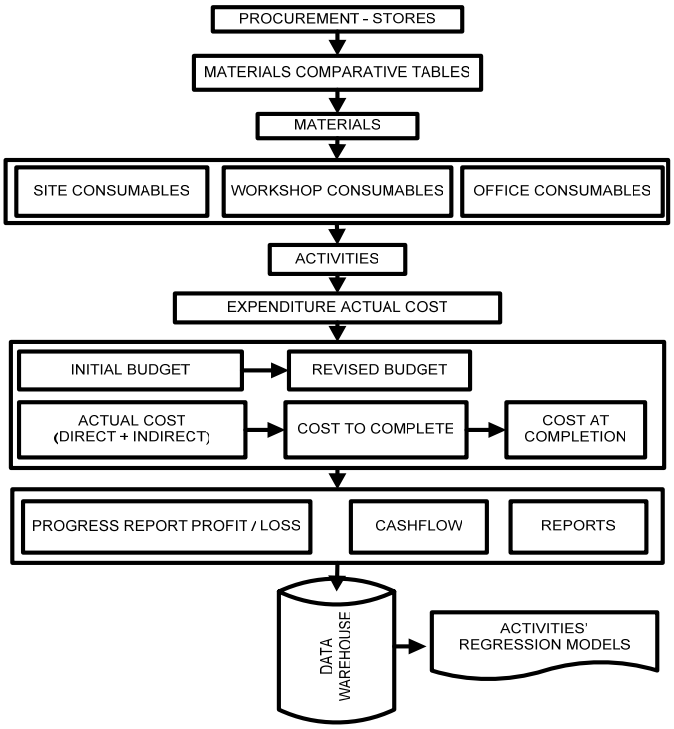

Figure 2: Material Cost Control System

In order to implement the presented material cost control system a number of MS Excel and Visual Basic for Application (VBA) based modules were deviced. The data monitoring and control should have a time

dependence in order to have a more holistic and effective project view. The main MS Excel based application consists of the following basic modules for the material monitoring and control:

- Consumables Till (a certain point in time)
- Consumables and Work Packages
- Summary

4.2 Spreadsheet Information Content and Structure

This section will present the above mentioned modules for material monitoring and control.

4.2.1 Consumables Till (a certain point in time) spreasheet

This spreadsheet classifies information on specific time instances. There is a hierarchy of project information. A general outline is as follows:

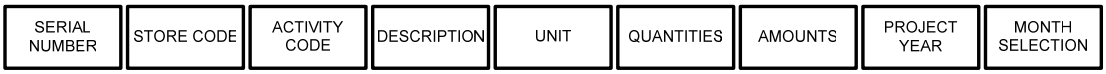

Figure 3: "Consumables Till" content

"Serial Number" and "Store Code" are typical ways for classifying information for accounting purposes. "Activity Code" is an alphanumeric representation (string) of the activity to which this item is ordered or belongs to. Use of standard coding systems is applied (e.g. Masterformat). The "Description" cell provides information on the type of material. Furthermore, the materials under the "Description" heading are classified as:

- Site Consumables
- Office Consumables
- Workshop Consumables

Cumulative cost can be obtained for each and every one of the mentioned categories. The "Unit" heading refers to the way the materials are measured depending on their type (e.g. Packet, Number, Box, Set, Roll, Meter, Crate, and Bundle). In the "Quantities" and "Amounts" column the data concerned is presented using the following structure and content:

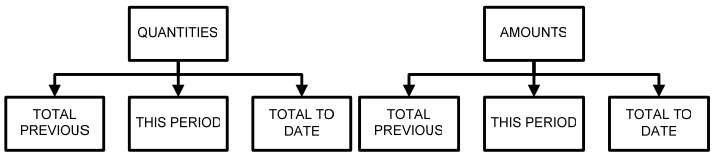

Figure 4: "Quantities" and "Amounts" data content

Under the "Project Year" category available information concerns "Total Quantity", "Total Amount" and "Basic Rates". Moreover, there is the possibility of presenting information on quantity, unit price and amount on a monthly basis per year.

4.2.2 Consumables and Work Packages spreasheet

This specific spreadsheet focuses control on the flow of materials. There is an examination of the materials received and materials incorporated. An outline of the spreadsheet headings is as in Figure 5:

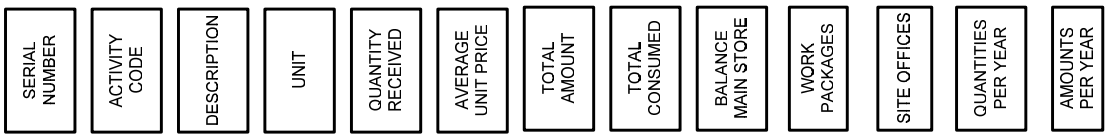

Figure 5: "Consumables and Work Packages" data content

This data facilitates monitor and control of material flow and provides various views for the material allocation to the project. One of the interesting characteristics is the "Work Packages". This column highlights the incorporation of materials in different project parts. Finally, cumulative information is presented, which is very useful, especially in projects that have long durations.

4.2.3 Summary spreasheet

This is the third and last spreadsheet of the material control module. As the title points out, its purpose is to concentrate information and present it in a way that facilitates monitoring, control and decision-making. It presents the allocation of cost per work package, through time and type of material.

4.2.4 Database

The database, presented in Figure 6, is one of the most valuable assets of the system. It records all the data and information concerning the financial behaviour of the project, especially, during construction. The database stores information in such a way that future projects can benefit from the data collected in each previous project. In an integrated manner with the excel spreadsheet, the access database collects the cost information of materials in relation with the activity that absorbs these materials. The same function will be executed between the database and each of the remaining Excel modules. The aim is to collect and centrally store the cost of resources for each activity. Special care is given to the codification of activities. Cost resource data can be used to provide models for activities, which can be used for cost projections in the project under construction and in future projects.

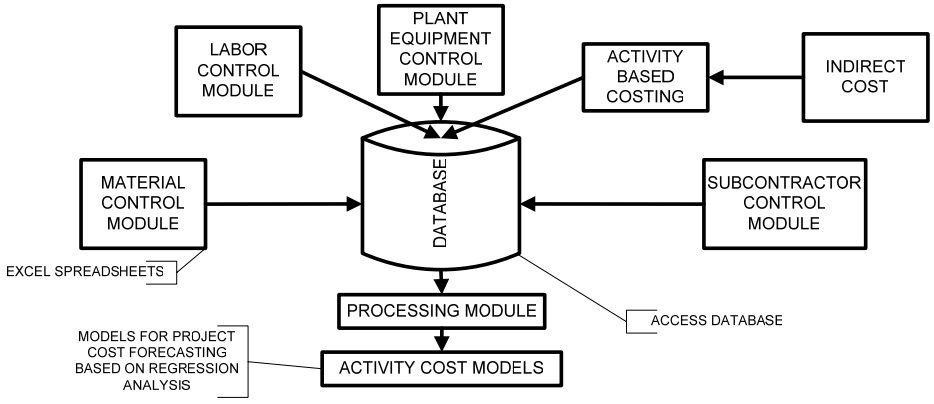

Figure 6: Database Description and Structure

5. Conclusions and Future Work

In a construction company, it is advisable that a special function for project monitoring and control be established. This function should be multidisciplined. It should bring together cost engineers responsible for the initial tender offer, design engineers, site constructors, procurement engineers, project and construction managers and quantity surveyors. This function should have at its disposal the available and appropriate technological means to accomplish its goals. The benefits from the efforts of such a function

would be discovered through successive projects and the knowledge accumulated should be added with each new project. This function will be responsible for managing data collection, process, control, information dissemination and the management of the appropriate actions as countermeasures to cost deviations. The information transcactions and the enabling technologies is also a subject of interest.

The intention is to provide better integration among the cost control modules and better adoption of time relationships and physical work progress. It is very important the system to be characterized by user friendliness and ease of learning. Certain improvements are required to be implemented in the system. The aim is to minimize the load of work and the repetitive tasks for an amateur user. Also automation minimizes the possibility of inserting errors and mistakes in the estimation. One essential issue is to avoid duplicate information in different spreadsheets, which is something that would confuse the amateur user and mislead him during the system's application.

On the other hand automating the system may sometimes prove dangerous because it creates a black box for the amateur user who is not aware of the algorithms and source code running behind the windows. There is also a need to minimize the number of spreadsheets. As part of future work, the system would be tested for accuracy, reliability and consistency. The goal is to identify the performance of the developed application by noting the deviations and accuracy of the results. Then, attention and special consideration should be applied to the deviations. The causes for the observed deviations will be identified and countermeasures to confront and eliminate these deviations will be implemented.

6. References

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