

A Computerized System for Managing Construction Materials for Gaza Strip Building Contractors

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Abstract—construction materials management process is a key to success of a construction project. Nowadays, successful management of construction materials has to be based on thorough and updated information, and processed utilizing a well designed construction materials management system.

The aim of this study has been to explore the local practice in construction materials management and develop a Computerized system to facilitate the management of construction materials mainly in the building construction. Construction materials management related literature has been generally reviewed; meanwhile some construction materials management system packages have been reviewed also.

A survey questionnaire supported by interviews is used to explore the local practice in construction materials management. One hundred and twenty questionnaires were distributed to contractors of first; second, and third class, eighty-four questionnaires were received and analyzed. The researcher concluded that all contracting companies are interested in using some techniques of managing construction materials such as creating and updating database for materials categories, local and international suppliers. Also, the Israeli closure on Gaza Strip is the main element that affects materials availability and cost and causes increase the cost of main materials such as cement, reinforcement steel and aggregate.

The study shows that most of contracting companies are still managing construction materials manually. Shortage of user-friendly construction materials system packages and lack of qualified personnel in using computer-based materials management systems are considered the main obstacles in using computer in construction materials management.

The researcher explores Microsoft Excel capabilities and utilizes these capabilities in developing a Construction Materials Management System which named "construction materials management system"(CMMS).

CMMS is a PC-based system which has been designed to run under Microsoft Windows. Microsoft Excel is used in developing CMMS, as most companies in Gaza strip are

familiar with it. Full description of CMMS has been given with detailed implementation procedures. CMMS has been evaluated to test its suitability to local practice. Evaluation of CMMS has addressed both conceptual and practical issues. One of the main recommendations of this research is to encourage local contracting companies to have a construction materials management system package and use it in determining the required quantities of construction materials in order to get materials in time and required quantities save time and minimize error.

Keywords— Construction projects, Gaza Strip, construction Materials, Computerized System.

I. INTRODUCTION

Construction materials constitute a major cost component in any construction project. The total cost of installed materials (or value of materials) may be 50% or more of the total cost [1], even though the factory cost may be a minor part of the total, probably less than 20-30%. This is because the manufactured item must be stored, transported, and restored before it is put in place or "consumed" at the site. The total cost of materials will include, in addition to the manufacturer selling cost, the cost of procurement (cost of placing processing and paying the material, physical distribution, the distributor's cost, and the transportation of materials), and the site-handling costs (cost of receiving, storage, issuing, and disposal)[2].

The efficient procurement and handling of material represent a key role in the successful completion of the work. It is important for the contractor to consider that there may be significant difference in the date that the material was requested or date when the purchase order was made, and the time at which the material will be delivered. These delays can occur if the contractor needs a large quantity of material that the supplier is not able to produce at that time or by any other factors beyond his control. The contractor should always consider that procurement of materials is a potential cause for delay [3].

Poor planning and control of materials, lack of materials when needed, poor identification of materials, re-handling and inadequate storage cause losses in labor productivity and overall delays that can indirectly increase total project costs. Effective management of materials can reduce these costs and contribute significantly to the success of the project.

1.1 Importance of Materials for a Project

Problems related to managing the flow of materials can be found in every organization. The efficient management of materials plays a key role in the successful completion of a project. The control of materials is a very important and vital subject for every company and should be handled effectively for the successful completion of a project. Materials account for a big part of products and project costs. The cost represented by materials fluctuates and may comprise between 20-50% of the total project cost and sometimes more. Some studies concluded that materials account for around 50-60% of the project cost [1].

Materials are critical in the operations in every industry since unavailability of materials can stop production. In addition, unavailability of materials when needed can affect productivity, cause delays and possible suspension of activities until the required material is available.

Unavailability of materials is not the only aspect that can cause problems. Excessive quantities of materials could also create serious problems to managers. Storage of materials can increase the costs of production and the total cost of any project. When there are limited areas available for storage, the managers have to find other alternatives to store the materials until they are needed. Some of these alternatives might require re-handling of materials, which will increase the costs associated with them. Provisions should be taken to handle and store the materials adequately when they are received. Special attention should be given to the flow of materials once they are procured from suppliers.

It is obvious that materials should be obtained at the lowest cost possible to provide savings to the company [4]. In the late 1970's, construction companies experienced an increase in costs and a decrease in productivity. Owners of these companies thought that these increases in cost were due to inflation and economic problems. Further research concluded that these companies were not using their resources efficiently and that the decrease in productivity was also attributable to poor management [1]. Material management has been an issue of concern in the construction industry. 40% of the time lost on site can be attributed to bad management, lack of materials when needed, poor identification

of materials and inadequate storage [8].

1.2 Material Management Steps

There are several steps within the scope of material management and each of these steps can give rise to potential problems. The more the responsibility is divided, the more potential problems that exist. Table 1 shows the steps in material management and the pertinent action related to these steps. Some actions are described in terms of the documentation produced, such as receiving report and vendor data [6].

Table.1: Material Management Steps

Sequence	Contribution action
1-RFQ (Requisition)	Drawings, specifications. Material bills Terms and conditions
2-Bids	Approved bidders list Pre qualification of bidders Bid evaluations
3-P.O. (Purchase Order)	Bid clarification Notice of award
4-Expediting	Vender data Manufacturer inspection Delivery Routings
5-Transport	Carrier and route Ownership en route Custom
6-Receiving	Inspection and acceptance Receiving report Storage
7-Inventory	Dispersal (i.e. material handling) Inventory level

II. METHODOLOGY

In this study, both quantitative and qualitative approaches are used. A structured questionnaire with personal interviews is used together in this research. The questionnaire is designed to get the factual information about local practices of contractors in managing construction materials in building projects as well as the opinions of contractors about these practices. One hundred and twenty questionnaires were distributed to contractors of first; second, and third class, eighty-four questionnaires were received and analyzed. The study is limited to Gaza strip contracting companies that are classified as first, second and third degrees, which have a valid registration in PCU. The subcontractors and contracting companies of fourth and fifth categories were excluded be-

cause these companies are too small to have specific arrangements for materials management.

The questions of the research questionnaire are constructed based on literature review and several interviews (39 interviews) with contractors to obtain different thoughts, which can be useful for creating questions. Methodology flow chart can be shown in Figure 1.

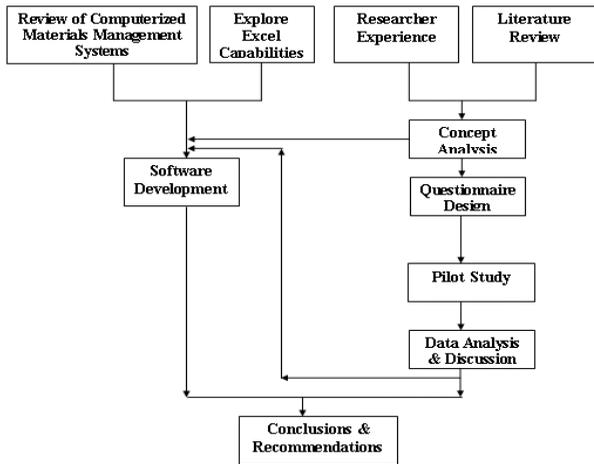


Fig.1: Methodology flow chart

III. RESULT AND DISCUSSION

3.1 Field of work

Table 2 demonstrates that all respondents are involved, in a way or another, in building works, (94.9%) are involved in water and sewerage works, and (95%) are involved in roads works. This show how important is the building construction to the construction industry in Gaza strip.

Table.2: Field of company specialization

Company work field		Main	Secondary	Unspecialized
Building work field	Frequency	75	6	0
	Percentage%	92.6	7.4	0
Water and sewerage works	Frequency	44	30	4
	Percentage%	56.4	38.5	5.1
Roads works	Frequency	44	32	4
	Percentage%	55.0	40.0	5.0

3.2 Computerized system

A Computerized system was be developed by the researcher to help the Gaza strip contractors to improve their practice in construction materials management. This system named Construction Materials Management System (CMMS). The system was built within Excel environment. It includes spreadsheets processed by number of functions which automate repetitive steps. Figure 2 illustrates a schematic diagram for CMMS. The system consists of four parts. Part one (input data and basic calculations), part two (materials purchase decisions), part three (materials cards), and part four (waste control).

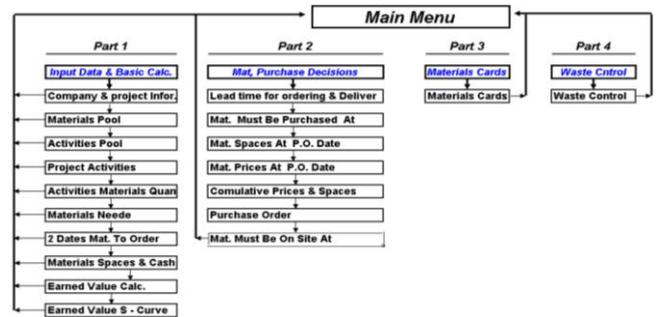


Fig.2: Construction Materials Management System (CMMS)

3.3 System description and components

CMMS basically consists of number of spreadsheets processed by functions. Template sheets with embedded formulas are also utilized to make CMMS more user friendly. The following is a general description of CMMS components.

3.3.1 Part one (Input data and basic calculations)

It includes basic input data about the company and the project, activities pool, materials pool, project activates, activities materials quantities, materials needed, "2 dates materials to order", materials spaces and cash requirements, earned value S-curve calculations, and earned value S-curve diagram. Basic input data can be either directly entered or electronically transferred, especially the project activities sheet, which can be transferred from the Microsoft project. The followings are details of the basic input data and calculations sheets.

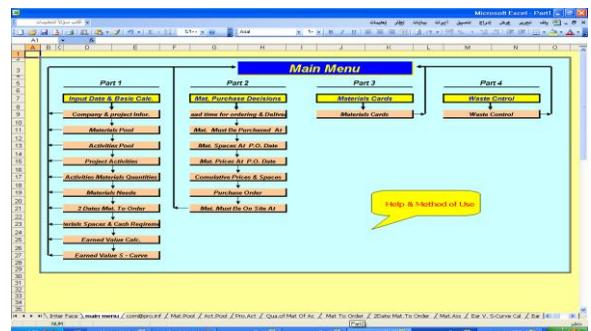


Fig.3: "Main Menu" sheet.

A. "Company and project information" sheet

"Company and project information" sheet involves data about the company like the company name, address, city, phone number, location, and fax number. It also includes data about the project like the project name, number, location, total cost, start date, and finish date. This sheet can be opened by clicking on the company and project information icon in the main menu. The data of the company and project can be entered by typing or electronic transmission. Once this is entered it automatically appears on the other sheets. The user can turn back to the main menu by clicking on "Back to Main Menu" icon at the bottom of this sheet. Figure 4 illustrates the company and project information sheet.

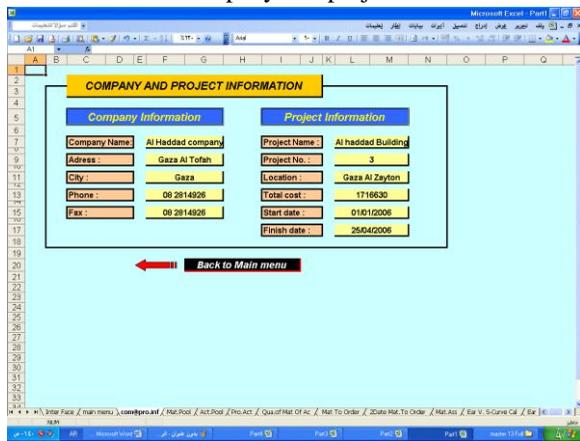


Fig.4: "Company and project information" sheet

B. "Activity pool" sheet

"Activity pool" sheet can be opened by clicking on the activity pool icon in the main menu. This sheet includes data about activity description, activity unit; activity pool code, materials name and its quantity, which is required for achieving one unit of an activity. These materials and quantities are entered for one time for all building projects. An activity code has four digits, the first two digits are reserved to main work type classification, the researcher assigned for example 01 for general works, 02 for earth works, 03 for concrete works, 04 for block works, 05 for plaster works, 06 for tiling works, 07 for painting works, 08 for carpentry works, 09 for metal and aluminum works, 10 for electrical works, 11 for mechanical works, 12 for isolation works, 13 for special works and 14 for finishing works. The other two digits are reserved to different work types such as building blocks works 10, 15 and 20 cm thick. The materials and its quantities which are used for one unit of activity are transferred into project activities sheet automatically and these quantities

are multiplied by total quantities of each activity.

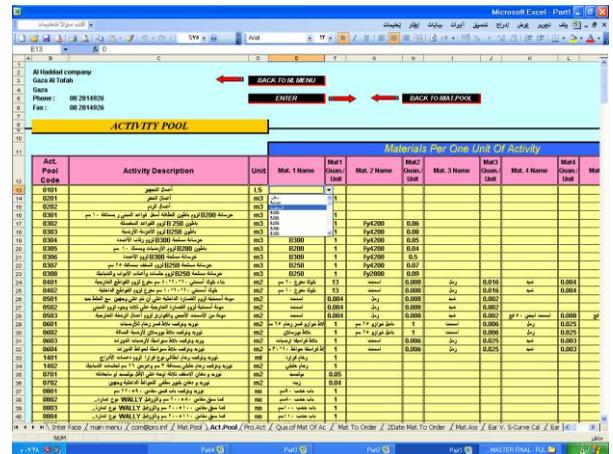


Fig.5: "Activity Pool" sheet

C. "Materials Pool" sheet

Materials pool sheet contains materials code, material name, material unit, the space needed to store one unit of the material and unit price. This data can be typed manually or transferred electronically from another sheet. Most of materials used in building works entered in the sheet for one time. Material unit can be typed or chosen from a list as shown in Figure 6.

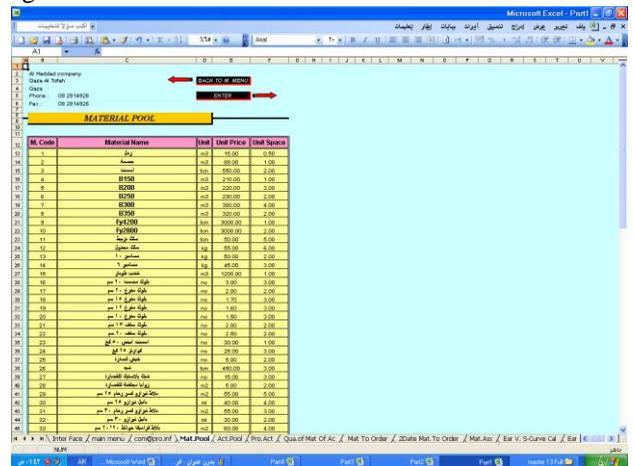


Fig.6: "Materials Pool" sheet

D. "Project Activities" sheet

"Project activities" sheet contains story number, activity pool code, activity description, unit, duration, start and finish dates, quantity, unit price and total price. This data can be obtained from Ms. Project by copying and pasting or typing manually. Activity code in this sheet must match the activity code in activity pool sheet. For example, B300 for column

works in activity pool sheet have the code number 0360. This activity in the project sheet must have the same code even if this activity used in any storey (The activity code of B300 for the ground floor column works is 0360, and the activity code of B300 for the tenth floor column works is the same code 0360). Figure7 shows a sample of project activities. Uniqueness of activity code is achieved by combining the storey No. and activity code.

Fig.7: "Project Activities" sheet

E. "Activities Materials Quantities" sheet

Figure 8 shows a sample of "Activities Materials Quantities" sheet. This sheet consists of story number, activity pool code, activity description, unit, total quantity, materials name, and its quantity, which is required for constructing the whole quantity for each activity. Materials names and materials quantity can be obtained automatically from activity pool sheet, but after the quantities be multiplied with total quantity for each activity. The user can turn back to the main menu sheet by clicking on Back to Main Menu icon at the top of this sheet. Also the user can open the "materials to order" sheet by clicking on Enter icon at the top of the sheet.

Fig.8: "Activities Materials Quantities" sheet.

F. "Materials Needed" sheet

Figure 9 shows a sample of "Materials Needed" sheet. This sheet contains story number, activity pool code, activity description, unit, total duration and total quantity, start and finish dates, the period of executing the activity and the distribution of materials according to the duration of the activity. This data can be obtained automatically from project activities sheet. Materials are equally distributed along the duration days of an activity. The user can turn back to the main menu sheet by clicking on Back to Main Menu icon at the top of this sheet, and he or she can open the "2 days materials to order" sheet by clicking on Enter icon at the top of this sheet.

Fig.9: "Materials needed" sheet

G. "Materials to Order between two Dates" sheet

"Materials to order between two dates" sheet contains material code, material description, and quantity of material. Figure 10 shows a sample of "2 dates materials to order" sheet. The data can be obtained by entering two dates at the top of this sheet. The user can return to the main menu sheet by clicking on Back to Main Menu icon, and he or she can open the "Materials spaces and cash requirements" sheet by clicking on Enter icon at the top of this sheet.

Fig.10: "Materials to Order between two Dates" sheet

Fig.12: "Earned value S-curve calculation" sheet

H. "Materials Spaces and Cash Requirements" sheet

Figure 11 illustrates "Materials Spaces and Cash Requirements" sheet. This sheet consists of story number, activity pool code, activity description, all materials and their quantities required for each activity, unit space, unit price, total space, and total price. From this sheet the user knows total material quantities, prices, and spaces required for each project activity. The user can return to the main menu by clicking on the Back to Main Menu icon at the top of this sheet, and he or she can open the "earned value S-curve calculations" sheet by clicking on Enter icon at the top of this sheet.

Fig.11: "Materials Spaces and Cash Requirements" sheet

I. Earned value S-curve calculations sheet

Figure 12 shows a sample of "Earned value S-curve calculations" sheet. It contains activity code, activity description, unit, start and finish dates, quantity, duration, unit price and total price. In this sheet, the user must enter the project start date and project finish date at the top of the sheet to obtain the total earned value for each activity. From this output information earned value S-curve is drawn and it can be used as a guideline for making a decision.

J. Earned value S-curve Sheet

It is a graph, which shows the cumulative earned value of the project against the time, (see Figure 13)

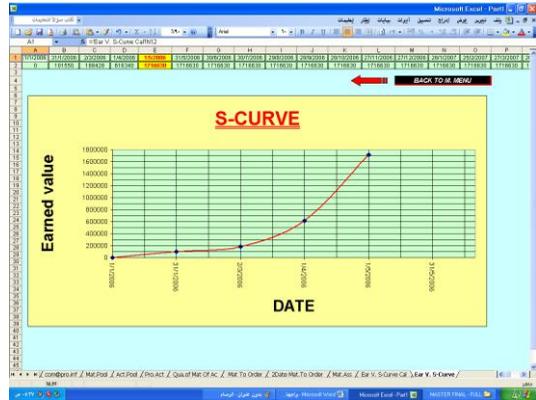


Fig.13: "Earned value S-curve" sheet

3.2.2 Part two (Materials purchase decision)

It includes the following sheets: "Materials to order and deliver on site" sheet; "materials must be purchased at" sheet; "materials spaces assignment" sheet; "materials prices assignment" sheet; "materials cumulative spaces sheet & prices at purchase order" sheet; "purchase order" sheet; and "materials must be purchased at" sheet. The followings are details of part two sheets.

A. "Materials to order and deliver on site" sheet

Figure 14 shows a sample of "materials to order and deliver on site" sheet. This sheet consists of material name, lead-time to order, and lead-time for delivery. In this sheet, in the column of "lead time for orders", the user should enter the number of days before which construction materials are to be ordered to have it available for delivery on time. The same thing he has to do for "lead time for delivery". The user can open "materials must be purchase at" sheet by clicking on Enter icon at the top of this sheet.

space and the available cash money. So the user can release a purchase order for this period by typing the start and finish dates of this period in purchase order sheet. He or she can open "Purchase Order "sheet by clicking on Enter icon at the top of this sheet.

and managing construction materials. The user can return to main menu sheet by clicking on Back to Main Menu icon at the top of this sheet.

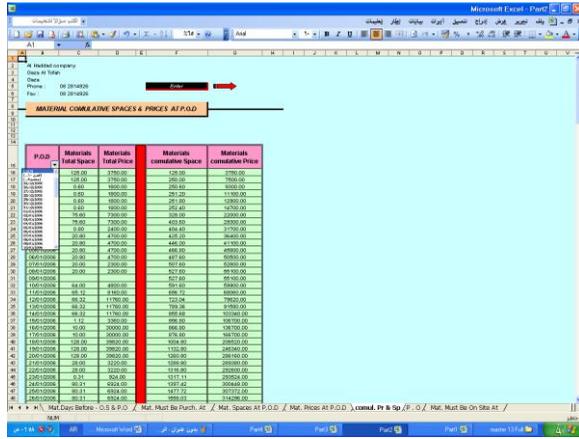


Fig.18: "Materials Cumulative Spaces & Prices at Purchase Order" sheet

F. "Purchase Order" sheet

Figure 19 shows a sample of "purchase order " sheet. This sheet consists of start and finish dates for purchase order, materials name, materials quantities, and unit. In this sheet, the user can obtain a purchase order for any period of the construction project by typing the start and finish dates in yellow colored cells. The user can open "Materials Must Be Purchased at" sheet by clicking on Enter icon at the top of this sheet.

Fig.20: "Materials must be on the site at" sheet

3.2.3 Part Three (Materials Card)

Part 3 has one sheet called "materials card" sheet. Figure 21 shows a sample of this sheet. It shows the distribution of a construction material on project activities. The user can choose the name of construction material from a list, and then the system will show the distribution of this construction material and its quantities. The user can return to main menu sheet by clicking on Back to Main Menu icon at the top of this sheet.

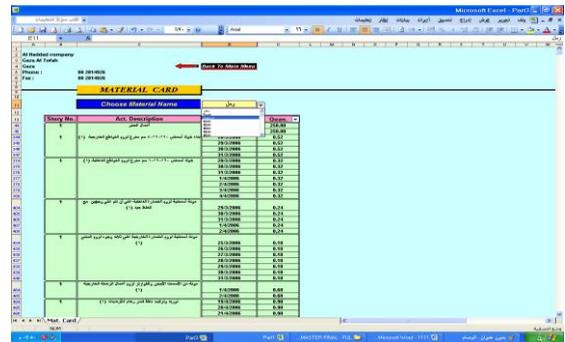


Fig.21: "Materials Card" sheet

3.2.4 Part 4 (Waste Control)

Part four has one sheet called "waste control" sheet. It consists of story number, activity pool code, activity description, unit, total duration and total quantity, start and finish dates, the stipulated activity duration in days, distribution of materials according to the duration of activities, earned quantity, consumed quantity, and percentage of waste. In this sheet, the user should fill earned and consumed quantities in earned and consumed columns day by day, and then the program calculates waste percentage for all materials as follows:

$$\text{Waste percentage \%} = (\text{consumed quantity} - \text{earned quantity}) * 100 / \text{earned quantity}$$

G. "Materials must be on the site at" Sheet

Figure 20 shows a sample of "Materials must be on the site at" sheet. CMMS provides data in this sheet automatically. This sheet consist of materials name, materials quantities. The purpose of this sheet is to help the user in controlling

No	Techniques	Strongly Agree	Agree	Intermediate	Weakly	Very weakly
1	Needed storage area report for project materials at any date.	3	1			
2	Required quantities of materials report project activities at any date.	2	1			
3	Actual cost report for project activities at any date.	4				
4	Required materials report to be purchased at any date.	2	1			
5	Required materials, to be available on site.	1	2			
6	Earned value S-Curve.	3	1			
7	Waste monitoring report for activity materials.	1	2			
8	Provide a card for any material and its assignment on projects` activities.	2	2			

Table.4: The contractors` responses to the features of CMMS design and structure.

No	Techniques	Strongly Agree	Agree	Intermediate-ly agree	Weakly agree	Very weakly agree
1	The system is flexible, and the data can be updated easily.	3	1			
2	In general, it is easy to use.	4				
3	It saves time and effort.	1	2			
4	Method of entering data is easy and clear.		3			
5	The reports and out-		4			

	puts are clear, and easy to read and understand.					
6	Method of sorting data is easy.	1	3			
7	Text and numbers shown are concise, and their sizes are suitable and readable.	3	1			
8	The information can be inquired easily.	2	2			
9	The method of use is understandable.	3	1			
10	It is easy to handle as it is developed within Excel environment.	2	1			
11	Training to use the CMMS is easy and it does not need much time. In addition, it does not need a professional user to deal with it.			2		
12	It can be applied for most of Gaza strip projects. (It is suitable for Gaza strip contractors).	3	1			
13	It contributes in improving the construction materials management practice in Gaza strip.	1	2			

Regarding the difficulties that the contractors were facing during the use of CMMS, almost all contractors said that they had not faced real difficulties. As for the criticisms or comments of the contractors, there are two main comments. The first is that materials quantities per one unit in the "materials pool" sheet have to be determined by experience. The second comment is the difficulty in determining the consumed and earned quantities for any materials used in the construction site day by day in the "waste control" sheet to determine waste percentage. On the other hand, the main advantages expressed by contractors are: CMMS is easy to

use and flexible; it helps the management staff in managing the construction materials in future projects; also, it helps the management staff to decide when and how much of materials quantities to be bought; and CMMS input-output relationships are reasonable. Overall, the results of evaluation indicate that CMMS tools and techniques are encouraging. Also, the contractors are generally satisfied with the design and structure of CMMS. Moreover, the contractors mention that a CMMS suite the Gaza strip contracting companies and has the potential to contribute in improving the construction materials management practice in Gaza strip. The researcher suppose that this edition of CMMS must use by contractors in the construction site, and another edition of this system after testing and evaluating will be used on home office and attached them together with website.

3.4.4 System Limitations

Some tools and functions are used in developing CMMS such as "macro" tool and "v-lookup" functions. The security level in MS Excel should be low to make full use of CMMS. The researcher tried to make use of the full capacity of Microsoft Excel. However, the following are the limits, which directly, affect the function of CMMS:

- Maximum number of project activities in Project activity sheet is 65,536 (affected by the capacity of Excel 2003).
- Maximum number of materials in materials pool sheet is 65,536 (affected by the capacity of Microsoft Excel)
- The number of materials that the user can enter in activity pool for each activity is five materials.
- Maximum duration for one activity is 30 units (days, weeks, months).

To use CMMS for a new project all yellow cells must be deleted by determining them and press "0" then presses Ctrl and Enter

IV. CONCLUSIONS

Construction Materials Management System (CMMS) was developed to satisfy some needs of Gaza strip contracting companies in managing construction materials.

The survey results show that contractors, in general, are interested in using many tools of managing construction materials. However, most contractors did not actually apply some tools and techniques of construction materials management such as: Creating database for materials categories, local suppliers, international suppliers, and materials cost. Updating database for local suppliers, international suppliers, materials cost when change, and using internet for knowing the new materials and its prices. Providing a list of materials in project, providing material cards at site store,

and recording the received materials on site.

Gaza strip contractors did not use any system to support project materials management. This gave the researcher a thrust to develop a computerized construction materials management system that supports and improves this practice. The researcher names this computerized system "construction materials management system" (CMMS). It was designed within Ms Excel environment where the results show that Ms Excel is the most used system by the contracting companies in Gaza strip.

CMMS provides many reports such as materials to order between two dates, materials assignments, waste control, when to purchase construction materials, when materials must be on the site, and purchase order between two dates.

CMMS provides the mechanism to decide when to buy construction materials and what quantities of construction materials the contractor need in the project.

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