

Evaluation of Material Management System for Construction Projects

*Aurealiz Alvarado Centeno
Civil Engineering
Auristela Mueses, Ph.D.
Civil Engineer Department
Polytechnic University of Puerto Rico*

Abstract — *The Aqueduct and Sewer Authority (AAA) made several improvements at a Water Treatment Plant located on the North Coast, of Puerto Rico with the intention of addressing several compliance issues that were identified by regulatory agencies. The project includes the installation of new equipment, relocation of existing pipelines, improvements to existing pump stations, construction of new processing systems that will be integrated into existing units and installation of new pipes. These improvements will focus on keeping the plant in compliance during peak flow events. The scope of this project consists on analyzing the Material Management of the Construction of a Waste Water Treatment Plant. This project will describe the importance of managing construction materials and will present a materials management plan that would improve the result and effectiveness of the project in terms of time and cost.*

Key Terms — *Cost, Management, Materials, Time.*

INTRODUCTION

This project is directed to the management of construction materials which will consist of an integrated process planning and control of all necessary efforts to ensure the quality and quantity of materials and equipment that are appropriately specified at the right time, and are obtained affordably and are available when needed. The materials management systems combines and integrates the "take-off" materials, supplier evaluation, purchasing, expediting, warehousing, distribution, communication, site management and scheduling.

The purpose is to show, in detail, the information needed for the management of a building materials system and the need for an integrated data system to provide this information. In this system it is important to consider that the amount of information is very large regarding the main operation of the materials. The information must be able to support the complete database cycle of the flow of materials: specific material identification, activities scheduling information, procurement, inspection report, quality control report, storage details, and inventory control.

Integrated systems are already operational in many large companies, and this trend is expected to grow as more and more companies realize that they need these systems to be more efficient. Information technology and business reengineering are finally starting to increase productivity.

BACKGROUND

Materials Management is simply the process by which an organization is supplied with the goods and services that are needed to achieve its objectives of buying, storage and movement of materials. Materials Management is related to planning, procuring, storing and providing the appropriate material of the right quality, the right quantity, at the right place, at the right time so as to coordinate and schedule the production activity in an integrative way for an industrial undertaking. Most industries buy materials, transport them into the plant, change the materials into parts, assemble parts in to finished products, and sell and transport the product to the customer. [1] All the activities related to purchase of materials, flow of materials, manufacture of the product, supply and sell the product at the market, require various types of

materials to manage and control their storage, flow and supply at various places. This is only possible to achieve by an efficient materials management.

The goal of materials management is to provide an unbroken chain of components for production to manufacture goods on time for the customer base. The materials department is charged with releasing materials to a supply base, ensuring that the materials are delivered on time to the company using the correct carrier. Materials is generally measured by accomplishing on time delivery to the customer, on time delivery from the supply base, attaining a freight budget, inventory shrink management, and inventory accuracy. The materials department is also charged with the responsibility of managing new launches.

Benefits

The effective materials management plan builds from and enhances an institutional master plan by filling in the gaps and producing an environmentally responsible and efficient outcome. An institutional campus, office, or housing complex can expect a myriad of benefits from an effective materials management plan. For starters, there are long-term cost savings, such as consolidating, reconfiguring, and better managing a campus’ core infrastructure that reduces annual operating costs. An institutional campus, office, or housing complex will also get the highest and best use out of campus real estate.

An effective materials management plan also means a more holistic approach to managing vehicle use and emissions, solid waste, hazardous waste, recycling, and utility services. As a result, this means a “greener,” more sustainable environment and a manifestation of the many demands today for institutions to become more environmentally friendly. In fact, thanks to such environmental advantages, creative materials management plans may qualify for LEED Innovation in Design credits. [2]

A sustainable materials management program starts with four simple questions:

- What is in it?
- Components
- Where is it coming from?
- Source
- How much of it is there?
- Usage level
- Where is it going when we are done using it?
- Disposal methods.

Finally, an effective materials management plan can improve aesthetics. Removing unsafe and unsightly conditions, placing core services out of sight, and creating a more pedestrian-friendly environment will improve the visual and physical sense of place for those who live and work there.

RESEARCH

The following are influencing factors in the material flow that need to be explored in the analysis of material management systems: scheduling, purchasing, warehousing, logistic, organization, management, control of materials, quality management and cost. Table 1 represents the original cost and time related to this project.

**Table 1
Original Time and Cost**

Notice to Proceed:	September 3, 2010	Start Date:	October 1, 2010
Original Cost:	\$1,362,498.00	Original Duration:	210 calendar days
Approved CO:	\$0.00	Original Substantial Completion (TS):	April 28, 2011
CO cost:	\$ 0.00	Final Termination Completion:	May 28, 2011
Revised Cost:	\$1,362,498.00	Extension Time Approved:	0 calendar days
Physical Progress:	0.00%	Approved Substantial Completion (TS):	April 28, 2011
Percent of Certification:	34.62%	Approved Termination Completion:	May 28, 2011

Description of the Problem

The poor management and handling of material resulted in some issues that affected the overall performance of the project. These issues were:

- Site Organization: The location of the administrative offices, storage and control point (input and output) at the project site, were not the best. This organization affects a

material flow into the site and access control to the site.

- Poor organization of Warehouse: This project does not have a standard method for identifying and warehouse control, much less an oversight by the person responsible for making purchases. The engineer, purchase manager and supervisor must always be aware of the available quantities of the materials and must plan to perform effective communication with suppliers. One observation regarding inadequate material management is that some materials stay outdoors of the facilities too long before being used. In places like Puerto Rico the weather conditions are very variable. Materials can be stored outdoors, unless the product characteristics may be affected. Another factor to consider is the waiting times for using or installing the material.
- Communication: Communication between the responsible parties was not effective. A situation arose concerning the operation of a pipe segment on the ground, which caused to stop construction activity in order to consult with the designer. After the designer evaluated the conditions, he recommended an increase in the amount and a change in the specifications of two valves (gate valve) previously submitted in the original contract documents. Moreover, the contractor had already proceeded to buy the equipment originally approved. Following the recommendations of the designer the contractor proceeded to emit a new purchase order with their suppliers located in Texas. This event affected the time of project because the order needed to be delivered to continue with the next activity.
- Delay in delivery of materials from the supplier: During a purchase order cycle the order delivery was delayed by responsibility of the supplier. The delay affects the logistic activity and the cost schedule of the project. For this reason the time and cost impact caused by the delay is not justified by the contractor,

and any claim therefore referenced to the delay was not approved.

- ARRA - Buy American: All construction projects in Puerto Rico with American Recovery Act funds need to buy materials and equipment under the contract clause called Buy American. To meet this clause is important that the material manager staff have good communication, planning and organization skills. In this particular project a purchase of the flow meter was made. Following an inspection of the product it was observed that it did not meet the specifications of Buy American. The flow meters had to be reordered and the delay in receiving the new order caused an impact on this issue; the project time duration was impacted by 12 days.

Problem Evaluation

- Site Organization: In all projects the site organization is very important and should consider the followings factors: location, access, size, existing storage facilities, lift capabilities and construction areas. In Figure 1, the general organization and location of the distribution building is not the most appropriate to facilitate the transportation, logistics, and movement of employees so that they can work in a safe environment and also meet the desired level of productivity. As observed in Figure 2, storage of materials is far from the place of security, because the parking obstructs the view from the management office. Another factor to be noted is that the area is very large, so employees have to walk quite a way to find any material that is needed to perform a task. The results are reflected in the low productivity of employees. A final factor to mention is that the entrance to the site is far related to the office. These situations make it difficult for the control vehicles that access the site to deliver materials and equipment.



Figure 1
Actual Organization Site (Aerial Project Photo, Project Documents)

- Poor organization of Warehouse: As shown in Figure 2, the materials are outdoors within the site, and are exposed to high temperature changes and lack of security. Mishandling of storage materials can result in a cost and product quality change. If a material is left outdoors the quality for which it was designed is degraded. If environmental exposures damage the main characteristics of the material, most likely it will need to be replaced by another top quality material, and thus result in an increase in cost.
- Communication: In any construction project the communication between the parties responsible for the management of material handling is important. In this particular project that is being analyzed, communication was very poor. A situation arises concerning the operation of a pipe segment on the ground, which caused it to stop construction activity to consult with the designer. Differences in site conditions were obtained and presented during zoom camera inspection, which showed as a result a backflow in a pipeline. The contractor submitted a Request for Information (RFI) regarding the different site condition situations. The designer evaluated the conditions, and recommended a change in the specifications of two valves (gate valves) previously submitted in the original contract documents. The

problem was that the contractor had already bought the equipment that had been originally approved. Based on the designer's recommendations the contractor proceeded to place a new purchase order with their suppliers located in Texas.



Figure 2
Storage Materials (Aerial Project Photo, Project Document)

Following the change, the contractor submitted a change order (Figure 3) to the owner of the project. The claim resulted in an increase in the cost of the project and a time extension of seven calendar days caused by a discrepancy in the contract documents submitted by the designer. In the claim to increase in cost of project life require a very long process between owner and contractor, so the impact can be longer than expected.

Figures 4 and 5 represent the order of the gate valves, which determines the difference in time between the purchase order and delivery of material. Time will obviously be claimed from the contractor on the basis of seven (7) calendar days between dates of November 12, 2010 to November 19, 2010.

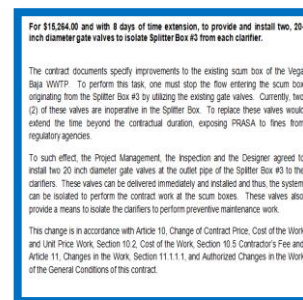


Figure 3
Item in the Change Order Claim (Project Documents)

time impact was not reflected. In this case there wasn't any impact but it is very important to include this aspect in the material management plan.

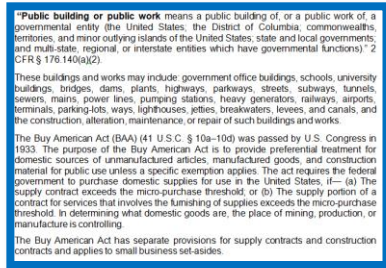


Figure 8
By American Act Definition (A Desk Guide to the Buy American Provisions of the Recovery Act- Feb. 2011)

Impact Summary

Table 2 shows an impact in time and cost for the delays and claim mentioned above.

After discussing the problems related to the materials management for the project under evaluation, the result was an increase in costs of \$28,160.00 for a cumulative change of 2.02% in the cost of the project. The new total project cost was \$1,390,658.00.

The time extension was 24 calendar days that represents a 10.25% in cumulative percentage change in the contract time. Presently, the project has reached 100% of construction progress. The Substantial Completion certification was granted on June 01, 2011.

RECOMMENDED MATERIAL MANAGEMENT PLAN

Next, will be present the recommendation plan based in the problem evaluation.

Personnel Organization

As part of the proposed Materials Management Plan for the Regional Waste Water Treatment Plant, it is recommended the creation of organizational responsibilities for each employee depending on their position based on experience and professional knowledge.

With this organization the planning tasks related to material handling can be executed depending on the schedule established in the work.

Table 2
Revised Times and Cost Project (Project Documents)

Notice to Proceed:	September 3, 2010	Start Date:	October 1, 2010
Original Cost:	\$1,362,498.00	Original Duration:	210 calendar days
Approved CO:	\$28,160.00	Original Substantial Completion (TS):	April 28, 2011
		Final Termination Completion:	May 28, 2011
Revised Cost:	\$1,390,658.00	Final Termination Completion:	
Physical Progress:	100%	Extension Time Approved:	34 calendar days
Approved Substantial Completion (TS):	June 01, 2011	Approved Final Termination Completion:	July 01, 2011

It is suggested, the materials manager to have a broad knowledge of the entire process and how materials relate to engineering, construction, and other functions.

It is also suggested as part of the plan for the site materials manager to know the relationship between the home and field offices, the construction operation, construction materials, and procedures for receiving, storage, and issue. Also, the employer must be known proficient in planning storage and issue facilities; and to understand computer systems, communication and coordination.

With a management plan, the Materials Controller, must know about inventory control, stocking, and issuing, and must be able to forecast (based on needs) field schedules, work packaging, bills of materials, and trial allocations. Also, warehouse supervisor needs to be familiar with different types of materials; knowledge of receiving, storage, and routine issue, and must have an understanding of bar coding, protection systems, documentation, and surplus disposal.

Figure 9 is the organization functional matrix recommended to this project.

The project didn't have a functional organization, and this recommended organization will help coordinate management methods and employees responsibilities because now they will be able to identify every resource to achieve their goals at work. Now the project has a structured functional organization whose efforts are coordinated to work towards the same goal in a dynamic environment.

Recommended Site

The organization recommended for the site is shown in Figure 10. This proposed change in layout will make it easier for material flow and the logistic in the project. Using two storage units will allow for materials to be better organized and classified by their type, priority of use and depending on these characteristics. Another advantage of this change in layout is that inventory can be updated because the materials are organized in a more efficient manner. In addition, there are other factors that can be improved with better organization: safety, supervision and favorable location at the time of work and transportation. [4]

The mobilization of the office is not necessary, but it creates a plan where a material controller can maintain control of the materials received and especially the date and time delivery.

In the construction period of project duration would have been very effective to consider prior actions on the matter of organizing the site. Would result in greater security for employees, fluid activities during execution thus greatly increase productivity. [5]

The appropriate site layout would result in greater security for employees, fluid activities during execution thus greatly increased productivity. By implementing a reorganization of the project site the material control procedure and storage of materials plan can be improved. This helps to have a constantly updated inventory and detailed register specifications for all received purchase order. Other positive impact is the increase of productivity because employees can now perform their duties in a safe and comfortable environment.

Material Control

After having presented the staff organization and presented the recommended site, you must set the steps in the project to achieve materials control. [3] An employee with responsibilities in any way related to material handling must meet the following factors:

- Do not accept materials that have not been ordered or are not according to specifications.
- It should be assured that the materials have been received and were charged the right prices for all expenses incurred.
- There must be adequate physical control over the storage of stock.

With the recommended materials management plan, all processes of material control data must be executed and recorded, following the steps indicated below:

- Input – Data should be collected and taken to a central block to be processed. The data in this case, called input, are classified to make the process easy and fast.
- Process – During the process, carry out necessary operations in order to convert data into meaningful information. When the information is complete run the output operation, which consists on preparing a report that will serve as a basis for decision making.

Personal Organization

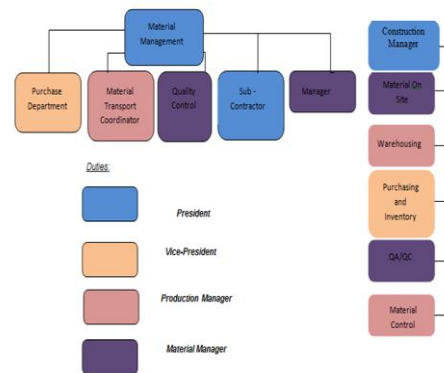


Figure 9
Functional Organization

- Output – The whole data processing is proposed as an additional activity; it includes the administration of the output results, which can be defined as the processes necessary to get useful information to the user.

By providing good material control, the estimates cost remain constant or the trend of change is

irrelevant. If any change in costs occurs, the impact should not be significant.



Figure 10
Recommended Site

When defining a material control plan, it is important to select an employee who is competent in the material area. This employee will be in charge of the status of process orders and the amount of material present in storage.

Organization of Warehouse

To achieve an effective material management the main goal is receiving, storage, control, and distribution of materials correctly at the job site. This is to avoid the problems that occurred earlier in this project, such as lost, damaged, misplaced, or improperly stored equipment and materials which resulted in expensive delays. [4] Ideally, purchase order line item descriptions by itemized bills of materials will be put into a computer database well in advance of shipment of materials; it is possible on site to update the materials status report using the report to update automatic receipt of inventory.

In this particular project, the ABC classification of materials strategies was used. ABC analysis is one of the simplest and standardized methods used by most of the firms for classification and storing a variety of materials. This is an important function of the materials management and production to help the purchasing department, the central office and the organization. The materials to be purchased and stored are recognized in the inventory by codes and nomenclatures. The inventory control of these various materials lies with the materials management department, the production department and the sales department.

Inventory at different levels is necessary to make ensure the availability of all these types of material.

The quality of the product manufactured by the organization depends upon the quality of the materials used to manufacture that product. It is a very important and necessary function of materials management to purchase the right quality of materials.

The Quality Plan for this project established that all employees carry out a detailed inspection when receiving an order. The inspection includes: the size and dimensional measurements within tolerance limits, which ensures the interchangeability and reliability of components and parts. The Inspector decides the quality scale of the product when checking the specifications compared with the order.

Important factors necessary in all products are: durability, dependability, high performance, reliability and aesthetic value. It is very essential because the quality of the materials also decides the selection of vendors and the relationship between buyers and suppliers. When inspection is complete the employer storage the material with their code classification and standardization method in the warehouse.

After making all the changes in the warehouse material the product must retain a high quality and must be stored at temperatures and other appropriate weather conditions. We can now conclude that the materials in this project will be stored according to what is established or recommended by the manufacturer. Also the material quality was protected. Therefore, the costs of replacing and rehabilitating is decreased and in many cases eliminated.

Communication

The most important function in materials management is communications. The home office of the contractor must be able to communicate information to the field and vice versa. The contractor must communicate materials status to the owner; the purchasing people must maintain communications with the engineer and the

contractor, and so forth. Figure 11, represents a simplified model of some of the communications links among organizational functions, showing materials management playing a key role. Communications are achieved through emails, data base server, meetings, written communication, or other means.

There are several potential problems in maintaining communications within an organization. The problems usually arise from people rather than from faulty technology or, there may be a lack of commitment or other complex factors that prevent communication.

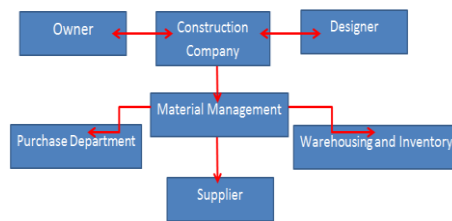


Figure 11
Communication Link

Personal communications breakdowns may occur for one or more of the following reasons: poor speaking and listening abilities, lack of understanding of the total materials management system concept, educational or technical barriers.

Communications go hand in hand with planning and control. Good communications must be planned and should anticipate the difficulties that are the result of misinterpretation of requirements or failure to understand what a good system can do.

The result of good communication is a management tool and guidance as to the duties provided for each employee, and their application depends on the policies, strategies and positions adopted by the company in every situation. Its great advantage, because all parties involved in the project was communicate about all management process. For example, an according to the availability of a specific material can identify the priority level regarding the scheduled activities and purchase. If the project had adopted this

communication link during the project duration, delayed days or even the additional cost for the purchase of the gate valves caused by the lack of communication between the designer and contractor, had not occur.

Supplier Evaluation

Vendors are selected in various ways. Contractor and owner companies usually have key suppliers; these are suppliers with whom they transact major purchases, who have certain technical capabilities, or who are leading commodity sources. These key suppliers frequently become sole sources for key equipment or materials. The purchaser may develop approved vendor lists, which are a modification of the key supplier list derived for the specific project. Past vendor performance is one criterion for being on this list; others are reputation, financial status, schedule and quality performance, shop capability, foreign versus domestic businesses and service performance. This last item can include considerations of local employment and effects on local economies.

After selecting the supplier, they proceed to the process of purchase orders, which are very important. These may include the following: Indemnity, Warranties, Insurance, Liquidated damages, Right of the purchaser to inspect and expedite, Assignment, Change cancellation for default, Dispute resolution and Compliance with local, state, and federal laws.

If the project on hand, had implemented this plan, the event of delayed delivery of the supplier could have been avoided, and therefore the time and cost of the project would not have been impacted.

The responsibilities of the Purchasing Department are:

- Provide an uninterrupted flow of materials, supplies and services required for the operation of the organization.
- Maintain quality control standards or appropriate measures.

- Find or develop competent vendors and if possible, standardize the role of the material. That is, if the purchase can be made in the amount of an item that can do the job, in place of two or three items that did the job previously.
- Purchase goods and services required for the lowest price possible, as long as they obtain the needed goods and services at the lowest possible price considering that the quality, delivery and service requirements are also satisfied.
- Sequence of activities to purchase equipment and fabricated materials usually follows a fixed sequence: planning and organization, develop lists of suppliers, etc.
- Selection of the terms and conditions of the order.
- Bid evaluation and recommendation.
- Negotiation and award.
- Issuance of Purchase Order.

The market price is a factor to be considered, if the market price fluctuates continuously purchasing policy "at request" would be more feasible in order to avoid the risk of loss. Contrary to this, if prices are stable for long periods the purchaser will opt for shopping "for later". But you should also consider the capital invested in inventories. Taking this factor into account, the policy would be to buy at request since it saves space in storage, and it would reduce the percentage of waste or damage, the risks of theft and unused capital could be allocated to other areas. The purchase order must contain the following: Date the order was placed, Name of supplier, Amount of material, Unit price, Total value (without tax), Percentage of tax and value, Total value with tax, Method of payment and the Date of delivery.

Our responsibility is to select suppliers to provide to its market quality products and having responsibility for complying with the provisions of the purchase process. Good suppliers help us avoid delays in purchase orders and the security of

working with the products as determined in the design's specification.

By following this recommended purchasing plan, the purchase manager would have selected a good supplier and the event of delayed delivery of the supplier could have been avoided, and therefore the time and cost project would have not been impacted.

Employer Education

In the case of returning the products by Buy American Act, the projects often apply laws and conditions that are fully regulated and guide the employees on their proper execution. This states that when the Principles of TQM and quality assurances are followed, there is still need for inspection to sample the process. This determination is made early in the engineering and procurement cycle, when the equipment and material are specified. In-plant inspection is limited to generally engineered items, permanent plant equipment, and critical, fabricated materials. The objective of the inspection is to ensure compliance with the specifications and statutory requirements.

Well educated employees provided greater security and personal motivation, being a chain of responsibility the positive impact is evident in the material management system. Increase productivity with decrease time and cost to specific or general project life.

Times and Cost Analysis with Recommended Plan

Table 3 presents the results in time and cost after the application of the recommended plan. To determine the cost and time impact after the recommended plan application, we assumed a conservative 10 percentage factor for the cost including different site conditions, design errors and any other discrepancies in the contract document. The analysis in impact time for the progress project is assumed as follows: each five (5) days impacted – one (1) day for potential impact represents acts caused by nature (God Acts) which the project management can't control.

After discussing the problems related to the materials management for the project under evaluation, the results were an increase in costs of \$2,816.00 for a cumulative change of 0.2% in the cost of the project. The new total project cost was \$1,365,314.00.

The time extension was 8 calendar days that represents a 3.8 % in cumulative percentage change in the contract time. Presently, the project has reached 100% of construction progress. The Substantial Completion certification was granted on May 06, 2011.

Table 3
Recommended Plan Analysis

Notice to Proceed:	September 3, 2010	Start Date:	October 1, 2010
Original Cost:	\$1,362,498.00	Original Duration:	210 calendar days
Approved CO:	\$2,816.00	Original Substantial Completion (TS):	April 28, 2011
Revised Cost:	\$1,365,314.00	Final Termination Completion:	May 28, 2011
Physical Progress:	100%	Extension Time Approved:	8 calendar days
Approved Substantial Completion (TS):	May 06, 2011	Approved Final Termination Completion:	June 05, 2011

RESULTS

As shown in Table 4, the difference in impacted cost between the current planning methods (traditional) is \$23,344.00. Equally, the difference in impacted time between the current planning methods (traditional) is 26 calendar days late. It is considered that the implementation of materials management system is totally positive in all areas of the project development. [6]

CONCLUSION

As shown in Table 4, the difference in impacted cost between the current planning methods (traditional) with the recommended plan is \$ 23,344.00. Similarly, the difference in impacted time between the current planning methods (traditional) with the recommended plan is 26 calendar days late. Figures 12 represent the time line analysis of the project without using material management system. While Figure 13 represents the time line analysis of the project with the application of recommended material management

system plan. It is considered that the implementation of materials management system is totally positive in all areas of the project development. The traditional method is largely very general and poorly organized. The reality is that common responsibilities like organization, planning, monitoring, and material management lack in a project management plan.

Table 4
Comparative Summary Table

Comparative Actual Plan VS Recommended Plan			
	Actual Plan	Recommended Plan	Difference Between Plans
I Cost	\$ 1,362,498.00	\$ 1,362,498.00	
ed Cost - Change Orders	\$ 28,160.00	\$ 2,816.00	
I Cost	\$1,390,658.00	\$ 1,365,314.00	\$ 25,344.00
I Time Duration (day)	210.00	210.00	
ed Time - COs (day)	34.00	8.00	26.00 days
I Time Duration (day)	244.00	218.00	
I Date(SC)	28-Apr-11	28-Apr-11	
I Date (TC)	28-May-11	28-May-11	
I Substantial Completion Date	1-Jun-11	6-May-11	
I Completion Date	1-Jul-11	5-Jun-11	

Actual Plan - Time Analysis

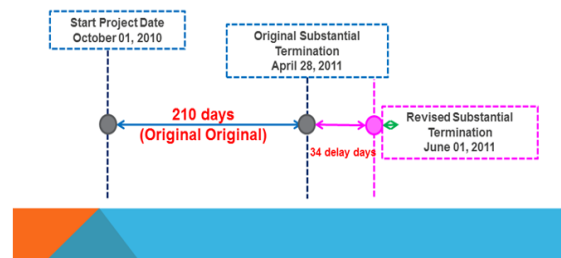


Figure 12
Actual Site Analysis – Time Line

Recommended Plan - Time Analysis

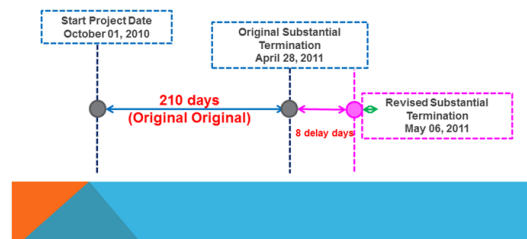


Figure 13
Recommended Site Analysis - Time Line

In projects constructed in this manner a cost caused by the material and/or quality lost is usually not considered in the original cost breakdown. It is demonstrated that improving the material management system have positive results and this will be reflected in a reduction in costs, increased storage capacity, improved efficiency, and increased productivity, reduction in the production time and optimized purchasing, among others.

These results will be reflected in a reduction of costs, in an increased storage capacity, an improvement in efficiency, and an increase in productivity, reducing the production time and optimizing purchasing, among other aspects.

RECOMMENDATIONS

During the analysis of the case study some recommendations are suggested for effective management of materials. In this project In this can improve a new technology system when includes programs for the use of identification systems such as bar code and electronic data interchange "EDI" [7], gives identification and tracking number to monitor the expending status of the purchase order. Generally, material management systems implementation would increase the efficiency of the whole process. Also, need to improve a document control staff to monitoring all projects documents. Advantage for this recommendation is to provide excellent service to our material managements system integrates in operations of manufacturing, warehousing and distribution, planning, logistics, transportation and location of materials.

Because a materials system plan must serve to integrate, coordinate, and monitor all the components of the materials management system, there are certain criteria that must be followed:

- It must be developed and included within the project plan.
- It must reflect corporate policies, priorities, and customer needs.
- This requires involvement education, and communications.
- It must include a schedule that meets the project engineering and construction requirements; if lead times or other factor

prevent this, the project plans must reflect the realities of such constraints.

- It must define materials responsibilities clearly for each major function.
- It must provide for more than just a computer database system. It is an integration of personal, information, and computer systems.

REFERENCES

- [1] Thomas, R. H., *et al.*, "Fundamental Principles of Site Material Management". J. Constr. Eng. Management. 131, 808 (2005).
- [2] Lambert, D.M., *et al.*, "Revista Internacional de Gestión de la Logística." Vol.9. nº 2. 1998.
- [3] Immer, J.R. "Manejo de Materiales". Editorial hispanoeuropea", 2da edición. Barcelona, España. 1971.
- [4] Lynch, K., *et al.*, "Planificación de Sitios". Tercera Edición, Cambridge, Mass.: Prensa MIT, 1984.
- [5] Rubenstein, H. M. "Una Guía para la Planificación de Sitios y Construcción Paisajista", 4ta Edición. New York, 2001.
- [6] López-Domínguez, M.S. Revista. "Logística internacional y globalización económica: dos modelos diferenciados" junio, 2007.
- [7] Kantor, M. "Electronic Data Interchange (EDI)". Instituto Nacional de Estándares y Tecnología, 2005.