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IMPROVEMENT OF THE PROJECT CONTROL SYSTEM:

A CASE STUDY OF AN INTERIOR DECORATION COMPANY

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A Thesis Submitted in Partial Fulfillment of the Requirements
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วิทยานิพนธ์ฉบับนี้ มีวัตถุประสงค์เพื่อกำหนดวิธีการในการลดความล่าช้า และงานเร่งที่ไม่จำเป็นของโครงการ โดยการปรับปรุงระบบควบคุมโครงการของบริษัทตกแต่งภายในแห่งหนึ่ง

เพื่อที่จะลดความล่าช้า และงานเร่งที่ไม่จำเป็นของโครงการ ได้มีการประยุกต์ใช้เทคนิคการวิเคราะห์โครงข่ายในระบบควบคุมโครงการที่นำเสนอ ในระบบควบคุมโครงการดังกล่าว ขั้นตอนของการวางแผน และการควบคุมโครงการ ถูกนำเสนอในลักษณะของระบบควบคุมย้อนกลับแบบวงจรปิด 4 ขั้นตอนคือ การวางแผนโครงการ, การกำหนดเวลางานโครงการ, การจัดสรรทรัพยากร และการควบคุมโครงการ ในส่วนของระบบควบคุมโครงการที่นำเสนอนั้น โปรแกรมการจัดการโครงการ Microsoft's Project 98 จะถูกนำไปประยุกต์ใช้กับ 4 ขั้นตอนข้างต้นเพื่อช่วยในการคำนวณ และแสดงผล

หลังจากได้มีการติดตามโครงการกรณีศึกษาหนึ่ง พบว่าโครงการเกิดความล่าช้าจากวันที่กำหนดไว้ 17 วัน และเวลาทำงานทั้งหมดที่เกิดขึ้นจริงมีค่ามากกว่าเวลาทำงานทั้งหมดที่วางแผนไว้ประมาณ 29.29% ในขณะที่ค่าแรงที่เกิดขึ้นจริง มีค่ามากกว่าแผนประมาณ 45.51% ทั้งนี้มีเป็นผลเนื่องจากข้อจำกัดในการประยุกต์ใช้ของระบบที่นำเสนออันเนื่องมาจาก 3 สาเหตุหลัก ดังต่อไปนี้

1. การขาดการยอมรับในตัวระบบที่นำเสนอจากหลายฝ่ายที่เกี่ยวข้องในโครงการ เนื่องจากความไม่พร้อมในการทำความเข้าใจกับทุกฝ่ายที่เกี่ยวข้อง ทั้งผู้รับเหมา และกลุ่มอื่นที่เกี่ยวข้อง และความมีบทบาทน้อยในโครงการกรณีศึกษาของผู้ศึกษา
2. การขาดความเข้าใจ และความคุ้นเคยของผู้เกี่ยวข้องในระบบที่นำเสนอ – การวิเคราะห์โครงข่ายงานและการใช้คอมพิวเตอร์
3. การขาดการศึกษาโครงการก่อนที่จะเริ่ม – ข้อจำกัดของที่ตั้งโครงการ และรายละเอียดของงานของผู้เกี่ยวข้องกลุ่มอื่น

อย่างไรก็ตามผู้วิจัยมีความเชื่อมั่นว่า หากมีการแก้ไขปัญหา และอุปสรรคต่างๆที่เกิดขึ้นดังกล่าวข้างต้น และมีการนำระบบที่เสนอไปประยุกต์ใช้กับโครงการดังกล่าว ในทางทฤษฎีโครงการจะเสร็จตรงตามกำหนดอันเป็นผลทำให้บริษัทไม่ต้องจ่ายค่าปรับ อีกทั้งยังไม่ต้องแบ่งวันทำงานของผู้จัดการโครงการให้กับโครงการดังกล่าวมากขึ้น ซึ่งจะทำให้บริษัทสามารถลดค่าใช้จ่ายที่เกิดขึ้นได้ประมาณ 160,400 บาท ในขณะที่ผู้จัดการโครงการก็จะสามารถดูแลโครงการอื่นได้เพิ่มขึ้น และเวลาในการทำงานที่ใช้ทั้งหมดของผู้รับเหมาของบริษัทที่ที่ตั้งโครงการจะลดลงจากที่เกิดขึ้นจริงประมาณ 38% อันเป็นผลทำให้ค่าแรงลดลงประมาณ 44%

ภาควิชา...ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต...	ลายมือชื่อนิสิต .....
สาขาวิชา.....การจัดการทางวิศวกรรม.....	ลายมือชื่ออาจารย์ที่ปรึกษา .....
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This thesis aimed to reduce the delay and unnecessarily accelerated or crashed activities of the project by improving the project control system of an interior decoration company.

To reduce the delay and unnecessarily accelerated or crashed activities of the project, the network analysis technique is applied in the proposed project control system. In the proposed project control system, four stages in planning and control the project are introduced in the closed loop feedback control system. They are project planning, project scheduling, resource allocation, and project control. In the proposed project control system, a project management software, Microsoft's Project 98, is applied in the combination of the four-mentioned stage to aid calculation and to display the results.

After tracking a case study project, it is found that the project delayed from the due date 17 days. And the actual total working time is about 29.29% more than the planed total working time; whereas, the actual total wage cost was estimated to more than the plan by 45.41%. However, these failure results were, partly, because of the limitation of the usage of the proposed project control system caused by three principal causes as follows:

1. The lack of the commitments to the proposed system from the involving groups due to poor communication with the other involving groups including the subcontractors and other involving groups, and the low role of the researcher in the case study project.
2. The lack of understand and familiarity with the proposed system of the involving individuals – the network analysis, and the computer usage.
3. The lack of studying the project before starting of the company – the site constraints and the details of other activities of other involving groups.

Anyway, the researcher believes that if these limitations mentioned above are solved and there is the application of the proposed system in the case study project, theoretically, the project will be finished on the due date leading to no paid fine. Moreover, no more project managers will be allocated to the project than expected. As the result, at least, the company will save about bath 160,400; whereas, the project managers can be allocated to more projects. And the overall working time of the company's subcontractors at the project site will be reduced by 38% from the actual usage leading to the reduction in the total wage 44%.

Department ..... The regional centre for manufacturing system engineering ..... Student's signature .....
Field of study ..... Engineering management ..... Advisor's signature .....
Academic year ..... 2000 ..... Co-advisor's signature .....

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Contents

Page

Contents (continued)

Page

Contents (continued)

Page

List of Figures

List of Figures (continued)

List of Tables

Chapter 1

Introduction

1.1 Background of the Research

This research is based on an interior decoration company, whose products and services are custom-made furniture, interior renovation, carpentry joinery works, and undertaken small, medium and major projects, such as supermarket, department stores, commercial spaces, hospitals, club house, residents, embassy and etc. The jobs of the company are made-to-order jobs that have many sizes. Some of these jobs could be operated in the factory of the company but many of them must be operated with subcontractors especially in project jobs that must be worked at the outside.

Many times, the projects tended to delay, leading to the unexpected cost. The unexpected cost comes from the increase in man, workdays, and etc., which are used to accelerate activities in order to complete the project on time. And if the project delays, the fine will be included in the unexpected cost. Moreover, these will also make the reputation of the company be degraded from unreliability and poor quality of the product. In order to gain more competitiveness, the project-control system of the company must be improved.

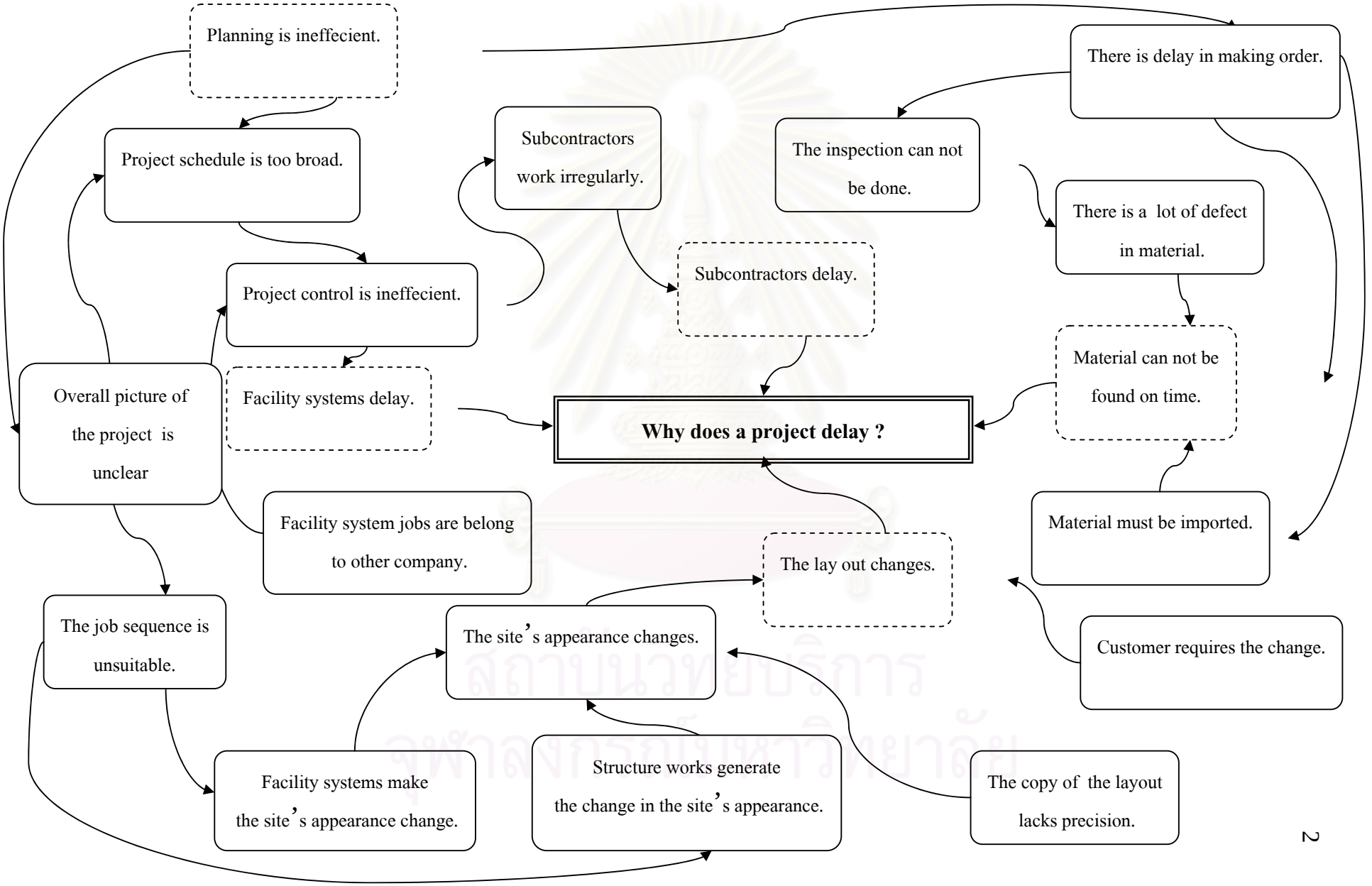
1.2 Statement of Problems

From the observation and analysis, there are four major reasons that will lead to the delay of a project. First, it is due to subcontractors. They usually operate slowly at the beginning of the project and this makes many projects seem to delay near the due date. Second, the delay is caused by materials that can not be prepared on time. Third, the delay could be come from the delay of making electric, air conditioning, and water-supply systems. Finally, the delay may be caused by the change in layout. This normally leads to the change in build-in furniture consuming an amount of unexpected time. However, all of the reasons mentioned above are, mainly, caused by poor project control system.

The principal cause leading to the poor control system is ineffective project planning. The ineffective project planning leads to too broad schedule, inconsiderable sequence of jobs in the project, unclear overall picture through the project, and unspecific material-requirement time. As a result, the project is controlled inefficiently. The relation of all mentioned above could be seen in the relation diagram as figure 1-1 in following page.

In regard to the current project planning and control system of the company, only Gantt chart is applied in the paper based system. In small project, this chart could be used to plan and control project, efficiently. However, it is rather unsuitable to be applied in medium and big projects that have much more complexity. These because Gantt chart is not a considerable tool to present relation and priority among jobs in the project. Moreover, it is also not flexible enough to be used to control projects that have frequent change in the project plan.

Figure 1-1: Relation Diagram



By the business nature of interior decoration, changes in the ongoing project plan always happened due to the customer's requirements. Thus, this implies that Gantt chart in the paper based system is too rigid to control the interior decoration project. In order to satisfy customers and to have more effective project control system, network analysis techniques should be applied within the computer based system.

1.3 Purposes of the Research

The objective of this research is to reduce the delay and unnecessarily accelerated activities of the project by improving the project control system of the company.

1.4 Scope of the Research

1. This research will focus on the medium project jobs of the company.
2. This research will cover activities from the project planning to the production control (see in figure 1-2).
3. The proposed project control system will be directly used to control material and shop floor production.

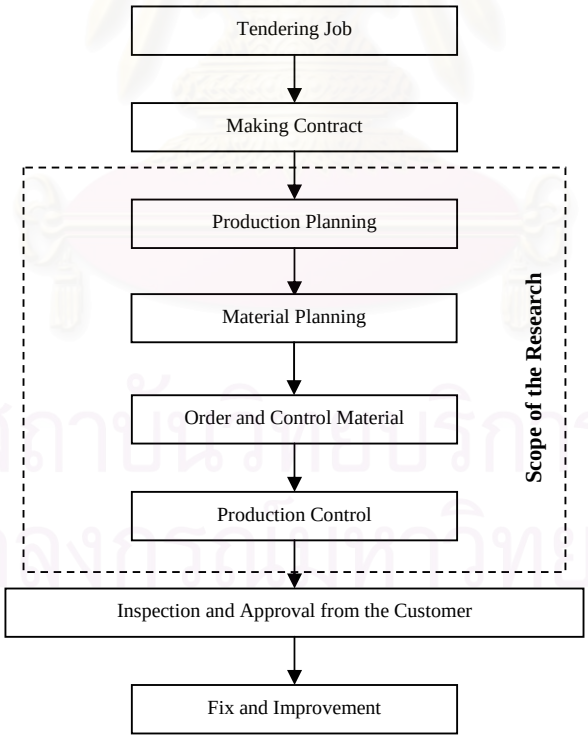


Figure 1-2: Flow diagram

1.5 Expected Results

The application of network analysis techniques will give clear overall picture through the project. As a result, the clear schedule could be made and used to control the project effectively. This also makes jobs and many problems that will occur in the project be foreseen in planning phase. Thus, the resources and the solutions of the problems, used through the project could be planed and managed. Moreover, the project plan and schedule will become more flexible to be revised or changed.

From the known resource, identified problems, and clear and flexible schedule, the project control system could be improved to control factors affecting the project efficiently. As a result, the delay and the unnecessarily accelerated activities of the project should be reduced. This will make the unexpected cost through the project be minimized.

1.6 Research Procedure

1. Observe and collect data
2. Analyze information
3. Plan to improve the project control system
4. Test and improve the proposed control system
5. Summarize the improvement and further development
6. Write up thesis and submit thesis form
7. Final examination

Chapter 2

Literature Survey

2.1 Concerned Theory

Jitrapa Ratanavaraha [1993] studied project management in establishing factory producing car-brake systems by using network analysis techniques.

Project management is the process by which the project manager plans and controls the task within the projects and the resources on which the organization by resource we mean:

- Money
- Manpower
- Equipment
- Facilities
- Materials
- Time (Schedule)
- Information and Technology

Donald W. Fogarty, Production & Inventory Management (1991)

Successful project completion requires timely monitoring of work completion and comparisons to scheduled completion.

Control of project is based on the following principles:

1. Plans should be realistic and not reflect an overstated estimate of capacity.
2. Control of the planning activity itself requires:
    a. Management commitment to the objectives of the plan and the availability of the resources

b. Agreement by the appropriate managers and supervisors that the precedence relationship, time estimates, and costs are realistic.

3. A performance reporting system with adequate, accurate, and timely information should exists. More project completion situations are dynamic. Changing conditions and actual performance initiation and completion may change priorities.

4. Procedures should exist for evaluating performance on a regular basis, for determining what, if any, corrective action is required, and for revising schedules and operating plans accordingly.

Eugene L. Magad, Total Materials Management (1995)

Materials management can be defined as an organizaitonal concept that fosters a total systems approach to plan, acquire, store, move, and control materials in order to optimize all company resources and provide customer service consistent with company policy.

- *Inventory Control*

Inventory control includes activities and techniques required to maintain materials at desired levels. Major activities includes:

1. Determing how much material will be required to satisfy company operational demands.

2. Maintaining detailed records of all materials available, ordered, and consumed.

3. Determing optimum order quantities; issuing requisitions.

4. Providing appropriate reports to and in decision making with regard to inventories.

- *Receiving and Stores*

Receiving and stores is responsible for activities related to receiving, storing, handling, issuing, and controlling materials. Major activities include:

1. Receiving materials which includes verification that the order was made and that the quantity received is correct, and preparation of a receiving report.

2. Storing receiving and inspected materials in accordance with efficient operating procedures that optimize use of space, equipment, personnel, and control of locations.

3. Issuing materials with authorized requisitions and accepting returned materials.

4. Maintaining control of physical counts to assure materials availability and performing periodic and annual physical inventories.

- *Material Handling*

Material handling involves both design and physical movement. It is the function of developing and implementing appropriate manual, mechanized, and automated systems to provide movement of materials throughout the company. Major activities include:

1. Analyzing company operations to determine the need for improved material handling.

2. Designing and justifying new materials handling systems that will provide increased production capacity, improved materials flow, reduced costs, improved working conditions, and reduced waste

3. Providing user-oriented material handing systems.

4. Transporting materials to and from storage areas and the point where they will be used.

J.R. Tony Arnold, Introduction to Material Management (1996)

Management management is a coordinating function responsible for planning and controlling materials flow to:

- Obtain the maximize utilization of the firm resources

- Provide the required level of customer service (project work)

Material management is a balancing act. The objective is to be able to deliver what customer want, when and where they want it at minimum cost. To achieve this objective, material management must make tradeoffs between the level of customer service and the cost of providing that service. Since costs rise as the service level increases, and material management must find the combination of inputs to maximize service and minimize cost.

- *Purchaing Cycle*

The purchasing cycle consists of the following steps:

1. Receiving and analyzing purchase requisitions.
2. Selecting suppliers. Finding potential supplies, issuing requests for quotations, receiving and analyzing quotations, and selecting the right supplier.
3. Determining the right price.
4. Issuing purchase orders.
5. Following-up to assure delivery dates are met.
6. Receiving and accepting goods.
7. Approving supplier's invoice for payment.

M. Pete Spinner.Improving Project Management Skills and Techniques 1989

Project management is defined in business and industry as managing and directing time, material, personnel, and costs to complete a particular project in and orderly, economical manner, and to meet established objectives of time, cost, and technical results.

Three major phases of a project, known as the project management cycle, are:

1. *Planning :* the initial phase of a project, where the plan of action is developed into a logical order and shown in an arrow diagram. The planning phase represents *what* work has to be done to complete the project.
2. *Scheduling :* the second phase of a project, detailing the time at which each job is to be started and completed. The times assigned for starting and completing activities are predicated on the float calculations of each of the

duration of the individual project items. The scheduling phase represents *when* the work needs to be done.

3. *Controlling :* the third phase of a project, in which the progress of the project is monitored as it gets under way.

There is no specific definition; however, there are several distinguishing characteristics associated with a project:

- A specific starting point and a specific end point
- Well-defined objectives
- A unique and not repetitious endeavor; cost and time schedules designed to produce a specified product or result; and
- Many organizational and functional lines involved in achieving the objectives.

Employing project management principles in planning, scheduling, and controlling projects, when applied properly, should ensure:

- A high degree of success in completing a project on time.
- And within the cost and labor and personnel budgets.

Among the principles that are used in projects are:

- Network planning
- Management by objectives
- Management by exception
- Cost analysis
- Labor and personnel allocation.

Definitions and areas of application of these principles are as follows:

- *Network analysis (or planning):* graphic analysis of a project, showing the plan of action through the use of a graphic diagram (used in project planning)

- *Management by objectives:* a technique that defines objectives and arranges a disciplined procedure to measure performance against the planned objectives (used in project planning and project control)

- *Management by exception:* a technique that signals the problems for which the manager's attention is needed (used in project control)

- *Cost scheduling:* distribution of project costs over the duration of the project

- *Cost minimizing:* a technique used to reduce the time required for completing a project with the least amount of additional cost

- *Resource allocation:* assigning resources to each project activity, such as labor, personnel, costs, and equipment

- *Resource leveling:* a method of scheduling activities within their available float times so as to minimize fluctuations in day-to-day resource requirements

Network planning and the associated project management principles are becoming increasingly popular in business. The benefits to be gained by using project management principles may have to be accepted on face value.

- ***Network Planning Techniques***

The principle most applied in project analysis is network planning (or network analysis). To understand network planning, one should review its history, have a knowledge of the differences between arrow diagramming and the conventional bar chart for graphical planning, and have a knowledge of the major diagramming techniques: the project evaluation review technique (PERT), the critical path method (CPM), and precedence diagramming (PCD).

The major differences between the *PERT* and *critical path* diagramming method over the years have gradually been reduced. One reason is that the critical path concept has adopted many of the PERT features.

The major differences between the PERT and critical path concepts are the following:

- PERT is "event oriented"; critical path is "activity oriented." (An event is a specific point in time, whereas an activity consumes time; therefore, PERT calculations provide starting and finishing times for the event, whereas critical path calculations provide for the starting and finishing times of the activity.)

- PERT calculates the probability of meeting a scheduled date; critical path has no provision for determining probabilities.

- PERT uses three time estimates for each activity; critical path uses one estimate.

Precedence diagramming is another form of graphic portrayal that has been popularized by the academic community and a number of hardware and software firms. The intent of this approacb is to simplify, as well as clarify, the planning diagrams. This is the case for some types of projects; however, to suggest a universal change in this method would result in inefficiencies in many planning programs that have used the conventional diagramming approach. The amount of improvement to be gained would not merit the retraining program that would be required.

Network diagrams overcome the deficiencies of bar chart construction, especially during the planning process, by providing the necessary information:

- Network diagrams explicitly show interrelations between jobs. A network diagram shows which jobs can be done concurrently, which ones precede, and which ones follow other jobs.

- Jobs with critical schedules are specified with their required beginning and completion dates.

- Jobs of a noncritical nature are also shown with optional beginning and end dates.

Using computer calculations based on the network diagram also permits more rapid and accurate updating of the project schedule.

For effective planning, more accurate information is required. Relationships among these jobs cannot be shown, and questions cannot be answered:

- What parts of these jobs can be done concurrently?
- What parts of each job must be completed before other parts begin?
- Must certain jobs or parts of jobs be given priority so as not to hold up scheduled completion of the project?
- Do some jobs or parts of jobs have optional starting and end dates, and what, specifically, are these optional dates?

However, the above questions can be answered by preparing a planning (or network) diagram for the project.

- *Benefits and Limitations of Network Planning*

Proper planning requires effort and dedication. Resolved in the benefits to be gained are the following:

- A disciplined basis for planning a project.
- A clear picture of the scope of the project that can be read and understood easily by someone who is not familiar (but knowledgeable of the network diagramming technique) with the project.
- A means of communicating what is to be done in the project.
- A vehicle for use in evaluating alternative strategies and objectives.
- A means of defining relationships among the project items.
- A means of pinpointing those responsible for accomplishing the jobs that make up the project.
- An excellent vehicle for training project personnel.

However, there are also some limitations in network diagrams to be concerned as follow:

- The network is often difficult to interpret.

- A great deal of time is usually needed to prepare changes, often requiring a great deal of time for making modifications to the network diagram.
- A network makes it difficult to note estimated costs versus actual costs.
- Individual skills are not recognized.

Roger G. Schroeder, Operations Management Decision Making in the Operations Function (1993)

A general sequence of management decisions required in all projects is:

- Planning
- Scheduling
- Control decisions

Planning refers to those decisions, required in the beginning of the project, which establish its general character and direction. Genally speaking, project planning establishes the major project objectives, the required resources, the type of organization used, and the key people who will manage and implement the project.

Major activities and decisions for good planning are as follow:

- Identify the project customer
- Establish the end product or service
- Set project objectives
- Estimate total resources and time required
- Decide on the form of project organization
- Make key personnel appointments (project manager, etc.)
- Define major tasks required
- Establish a budget

The scheduling phase of project management specifies the project plan in more detail. This phase begins with the construction of a detailed list of project activities, called a work-breakdown structure. A detailed time schedule for each activity in the work-breakdown structure. A detailed time schedule for each activity in the work-breakdown structure is then established. Followed by a time phase budget which is keyed to the start and completion times of each of the project activities can be developed. Thus, the project personnel can be assigned to individual project activities.

Major activities and decisions for proper scheduling are as follow:

- Develop a detailed work-breakdown structure
- Estimate time required for each task
- Sequence the tasks in the proper order
- Develop a start/stop time for each task
- Develop a detailed budget for each task
- Assign people to tasks

- *Scheduling Methods*

There are several type of scheduling methods in use, such as:

1. Gantt chart
2. Network methods
3. Constant-time networks (assume the constant time for each activity)
4. PERT network method
5. Precedence diagramming method

Project control is maintained by monitoring each activity as the work is performed on the project. Activities should be monitored for time, cost, and performance in accordance with the project plan. When a significant discrepancy exists between actual results and the plan, corrective action should be taken. These corrective actions might

include revision of the plan, reallocation of funds, personnel changes, or other changes in resources. As a result of corrective actions, the plan should once again be feasible and realistic.

Major activities and decisions for effective controlling are as follow:

- Monitor actual time, cost, and performance
- Compare planned to actual figures
- Determine whether corrective action is needed
- Evaluate alternative corrective actions
- Take appropriate corrective action

- *Use of Project Management Concepts*

Project management requires a great deal more than scheduling. Planning for the project is required before the scheduling begins, and control is required after the schedule is developed. Project management requires a blend of behavioral and quantitative skills. Thus, scheduling methods should be seen as only one part of a complete approach to project management.

In selecting project scheduling methods, a conscious tradeoff should be made between sophisticated methods and cost. Gantt chart methods should not be seen as outdated or naive. Rather, Gantt charts are justified for projects where the activities are not highly interconnected or for small projects. In these cases where the Gantt chart is warranted, a network method may not provide enough additional benefits in relation to its costs.

If a network method is justified, a choice must be made between constant time, PERT, CPM, PDM< or more advanced methods. The constant time method is adequate for cases where activity times are constant or nearly so. If activity times are random, a PERT network should be chosen to reflect the uncertainty directly. PERT may therefore be applied to situations such as R&D, computer system design, and military invasions, where activity times are expected to vary.

CPM methods, on the other hand, should be used where activity times are fairly constant but can be reduced by spending more money. CPM might apply in cases such as construction projects, installation of equipment, and plant startup and shutdown. More advanced network methods include generalized networks and resource-constrained situations. These methods are still in development and have not been widely used in practice.

The PDM method has been gaining in use because of its ability to display schedules conveniently and to represent complex precedence relationships. In practice, PDM has been found to be easy to use and easy to explain to people who are not familiar with networks.

Network scheduling methods are usually computerized in practice. A large number of different standard software packages are available to cover the entire range of scheduling methods. These packages not only support scheduling but also assist in project accounting and in controlling progress.

Jack R. Meredith and Samuel J. Mantel, Jr., Project Management A Managerial Approach (2000)

A schedule is the conversion of project action plan into an operating timetable. As such, it serves as the basis for monitoring and controlling project activity and, taken together with the plan and budget, is probably the major tool for the management of projects. In a project environment, the scheduling function is more important than it would be in an ongoing operation because projects lack the continuity of day-to-day operations and often present much more complex problems of coordination. Indeed, project scheduling is so important that a detailed schedule is sometimes a customer specified requirement. Due to the fact that a properly designed, detailed schedule can also serve as a key input in establishing the monitoring and control systems for the project.

The basic approach of all scheduling techniques is to form a network of activity and event relationships that portrays the sequential relations between the tasks in a project. Such a network is a powerful tool for planning and controlling a project, and has the following benefits:

- It is a consistent framework for planning, scheduling, monitoring, and controlling the project.
- It illustrates the interdependence of all tasks, work packages, and work elements.
- It denotes the times when specific individuals must be available for work on a given task.
- It aids in ensuring that the proper communications take place between departments and functions.
- It determines an expected project completion date.

- It identifies so-called critical activities that, if delayed, will delay the project completion time.

- It also identifies activities with slack that can be delayed for specified periods without penalty, or from which resources may be temporarily borrowed with, out harm.

- It determines the dates on which tasks may be started-or must be started if the project is to stay on schedule.

- It illustrates which tasks must be coordinated to avoid resource or timing conflicts.

- It also illustrates which tasks may be run, or must be run, in parallel to achieve the predetermined project completion date.

- It relieves some interpersonal conflict by clearly showing task dependencies.

- It may, depending on the information used, allow an estimate of the probability of project completion by various dates, or the date corresponding to a particular a priori probability.

- ***Network Techinques: PERT AND CPM***

With the exception of Gantt charts, the most common approach to project scheduling is the use of network techniques such as PERT and CPM.

In application, PERT has primarily been used for R&D projects, the type of projects for which it was developed, though its use is more common on the "development" side of R&D than it is on the "research" side. CPM was designed for construction projects and has been generally embraced by the construction industry.

The two methods are quite similar and are often combined for educational presentation. Originally, PERT was strictly oriented to the time element of projects and used probabilistic activity time estimates to aid in determining the probability that a project could be completed by some given date. CPM, on the other hand, used deterministic activity time estimates and was designed to control both the time and cost aspects of a project, in particular, time/cost trade-off. In CPM, activities can be "crashed" (expedited) at extra cost to speed up the completion time. Both techniques identified a project critical path whose activities could not be delayed, and also indicated activities with *slack* (or *float*) that could be somewhat delayed without lengthening the project completion time.

- ***Terminology***

The definitions of term used in our discussion of networks

Activity A specific task or set of tasks that are required by the project, use up resources, and take time to complete.

Event The result of completing one or more activities. An identifiable end state occurring at a particular time. Events use no resources.

Network The combination of all activities (often drawn as *arcs*) and events (often drawn as *nodes* at the beginning and end of each arc) defines the project and the activity precedence relationships. Networks are usually drawn starting on the left and proceeding to the right. Arrowheads placed on the arcs are used to indicate the direction of flow-that is, to show the proper precedence. Before an event can be *realized*-that is, achieved-all activities that immediately precede it must be completed. These are called its *predecessors*. Thus, an event represents an instant in time when each and every predecessor activity has been finished. Tbey are merely points on the network, conditions of the system that can be recognized.

Path The series of connected activities (or intermediate events) between any two events in a network.

Critical Activities, events, or paths which, if delayed, will delay the completion of the project. A project's *critical path* is understood to mean that sequence of critical activities (and critical events) that connect the project's start event to its finish event.

In transforming a project plan into a network, one must know what activities comprise the project and, for each activity, what its predecessors (and/or successors) are.

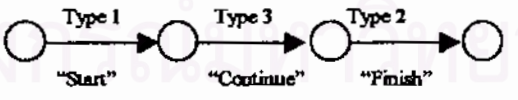


Figure 2-1: These sequential activities, AOA format

An activity can be in any of these conditions:

(1) It may have a successor(s) but no predecessor(s),

(2) It may have a predecessor(s) but no successor(s), and

(3) It may have both predecessor(s) and successor(s).

The first of these is an activity that starts a network. The second ends a network. The third is in the middle. Figure 2-1 shows each of the three types of activities. Arrows are labeled with the appropriate type numbers. More than one arrow can start a network, end a network, or be in the middle. Any number of arrows can end at a node or depart from a node.

The interconnections depend on the technological relationships described in the action plan.

Another format for drawing networks is AON (activity-on-node). In this case, activities are represented by nodes (usually shown as rectangles) with arrows to show the precedence relationships. In AON notation, when there are multiple activities with no predecessors, it is usual to show them all emanating from a single node called "start." Similarly, when multiple activities have no successors, it is usual to show them connected to a node called "end," as in Figure 2-2.

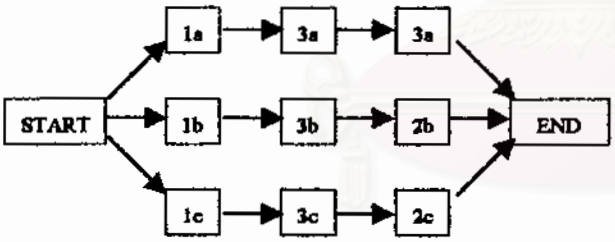


Figure 2-2: Activity network, AON format.

- *Extensions and Applications*

There have been a large number of extensions to the basic ideas of PERT and CPM. These extensions are often oriented toward handling rather specific problem situations through additional program flexibility, computerizing some of the specific problems, fine-tuning some of the concepts for special environments, and combining various management approaches with the PERT/CPM concepts.

One interesting extension deals with the case when it is very difficult to estimate activity times because no one has experience with the activity, or because the activity is ill-defined.

- *Precedence Diagramming*

One shortcoming of the PERT/CPM network method is that it does not allow for leads and lags between two activities without greatly increasing the number of sub-activities to account for this.

Precedence diagramming is an AON network method that allows for these leads and lags within the network. Because of the increased flexibility regarding required lead and lag times, it must be known whether each activity can be split or not. Splitting allows easier satisfaction of the lead and lag restrictions. If splitting is not allowed, the project may be significantly delayed.

Also, the critical path of the network will frequently go backward through an activity, with the result that increasing the activity time may actually decrease the project completion time. Such an activity is called *reverse critical*. This happens when the critical path enters the completion of an activity through a finish constraint, continues backward through the activity, and leaves through a start constraint.

Network node times are calculated in a manner similar to PERT/CPM times. Because of the lead and lag restrictions, it is often helpful to lay out a Gantt chart to see what is actually happening.

Precedence diagramming seems to be gaining in popularity. The richer set of precedence relationships it allows is pertinent for a variety of projects, particularly construction projects.

- *GERT*

The Graphical Evaluation and Review Technique (GERT) is a network model developed to deal with more complex modeling situations than can be handled by PERT/CPM. GERT combines signal flow-graph theory, probabilistic networks, PERT/CPM, and decision trees all in a single framework. Its components consist of *logical nodes* (defined below) and *directed arcs* (or branches) with two parameters; the probability that a given arc is taken (or "realized") and the distribution function describing the time required by the activity. Evaluation of a GERT network yields the probability of each node being realized and the elapsed time between all nodes.

At this point, it may be useful to compare GERT and PERT/CPM in order to focus on what is different about GERT.

GERT	PERT/CPM
Branching from a node is probabilistic	Branching from a node is deterministic.
Various possible probability distributions for time estimates.	Only the beta distribution for time estimates.
Flexibility in node realization.	No flexibility in node realization.
Looping back to earlier events is acceptable.	Looping back is not allowed.
Difficult to use as a control tool.	Easy to use for control.
Arcs may represent time, cost, reliability, etc.	Arcs represent time only.

While there are computer programs that optimize PERT/CPM problems, GERT and its various enhancements are computer simulations.

The steps employed in using GERT are as follow:

1. Convert the qualitative description of the project action plan into a network, just as in the use of PERT/CPM.

2. Collect the necessary data to describe the arcs of the network, focusing not only on the specific activity being modeled, but also on such characteristics of the activity as the likelihood it will be realized, the chance it might fail, any alternative activities that exist, and the like.

3. Determine the *equivalent function* of the network.

4. Convert the equivalent function of the network into the following two performance measures:

   The probability that specific nodes are realized.

   The *moment generating function* of the arc times.

5. Analyze the results and make inferences about the system.

- ***Resource Leveling***

Resource leveling aims to minimize the period-by-period variations in resource load by *shifting tasks within their slack allowances*. The purpose is to create a smoother distribution of resource usage.

There are several advantages to smoother resource usage. First, much less hands on management is required if the use of a given resource is nearly constant over its period of use. The project manager can arrange to have the resource available when needed, can have the supplier furnish constant amounts, and can arrange for a backup supplier if advisable. Moreover, the project manager can do this with little error. Second, if resource usage is level, the project manager may be able to use a "just-in-time" inventory policy without much worry that the quantity delivered will be wrong. If the resource being leveled is people, leveling improves morale and results in fewer problems in the personnel and payroll offices because of increasing and decreasing labor levels.

Not only are there managerial implications to resource leveling, there are also important cost implications. When resources are leveled, the associated costs also tend to be leveled. If resource use increases as time goes by, and if resources are shifted closer to the present by leveling, costs will be shifted in the same way. The opposite is true, of course, if resource usage is shifted to the future. Perhaps most important from a cost Perspective is leveling employment throughout a project or task. For most organizations, the costs of hiring and layoff are quite significant. It is often less expensive to level labor requirements in order to avoid hiring and layoff if it means some extra wages will be paid. The project manager must be aware of the cash flows associated with the project and of the means of shifting them in ways that are useful to the company.

Resource leveling is a procedure that can be used for almost all projects, whether or not resources are constrained. If the network is not too large and there are only a few resources, the leveling process can be done manually. For larger networks and multiple resources, resource leveling becomes extremely complex, far beyond the power of manual solutions. Fortunately, a number of computer programs can handle most leveling problems efficiently.

- ***Constrained Resource Sheduling***

There are two fundamental approaches to constrained allocation problems:

1. Heuristics approach
2. Optimization model

Heuristic approaches employ rules of thumb that have been found to work reasonably well in similar situations. They seek better solutions. Optimization approaches seek the best solutions but are far more limited in their ability to handle complex situations and large problems. We will discuss each separately.

Most PC software designed for project management will level resources and solve the problems of over-scheduling resources. They require priority rules to establish which activities take precedence.

Heuristic Methods

Heuristic approaches to constrained resource scheduling problems are in wide, general use for a number of reasons.

1. They are the only feasible methods of attacking the large, nonlinear, complex problems that tend to occur in the real world of project management.

2. While the schedules that heuristics generate may not be optimal, they are usually quite good-certainly good enough for most purposes.

Commercially available computer programs handle large problems and have had considerable use in industry.

Most heuristic solution methods start with the PERT/CPM schedule and analyze resource usage period by period, resource by resource. In a period when the available supply of a resource is exceeded, the heuristic examines the tasks in that period and allocates the scarce resource to them sequentially, according to some priority rule. The major difference among the heuristics is in the priority rules they use. Remember that the *technological necessities always take precedence.*

Optimizing Methods

The methods to find an optimal solution to the constrained resource scheduling problem fall into two categories: mathematical programming (linear programming for the most part) and enumeration. In the 1960s, the power of linear programming improved from being able to handle three resources and 15 activities to four resources and 55 activities. But even with this capacity, linear programming is usually not feasible for reasonably large projects where there may be a dozen resources and thousands of activities.

In the late 1960s and early 1970s, limited enumeration techniques were applied to the constrained resource problem with more success. Tree search and branch and bound

methods were devised to handle up to five resources and perhaps 200 activities. Advances in linear programming techniques now allow linear programming to be used on large constrained resource scheduling problems.

- *Computerized Project Management Information Systems*

Real projects are often extremely large, with hundreds of tasks and thousands of work units. Diagramming, scheduling, and tracking all these tasks is clearly a job for the computer, and computerized project management information systems were one of the earlier business applications for computers. Initially, the focus was on simple scheduling pack, ages, but this quickly extended to include costs, earned values, variances, management reports, and so on.

The earlier packages ran on large, expensive mainframe computers; thus, only the larger firms had access to them. Still, the use of these packages for managing projects on a day-to-day basis was not particularly successful. This was because of the inability of project managers to update plans in real time, mainframe computers typically being run in a batch rather than online mode. With the development and proliferation of microcomputers, and the corresponding availability of a wide variety of project management software, project managers use one or more project management information systems.

These new microcomputer-based project management information systems are considerably more sophisticated than earlier systems and use the microcomputer's graphics, color, and other features more extensively. Many systems can handle almost any size project, being limited only by the memory available in the computer. Many will handle multiple projects and link them together to detect resource over-allocation;

- *Current Software*

The explosive growth of project management software during the early 1990s saw the creation of more than 500 packages. This software came in a wide variety of capabilities and prices. The mainstream products have roughly similar capabilities, with each having its individual strengths and weaknesses. The simple fact that the lower cost programs generally do not have the ability to do everything an experienced project manager might want has led to the rapid growth of a different type of software, the "add-on." *Add-on software is specially crafted to accomplish specific tasks and to be fully compatible, sometimes almost seamlessly so, with specific general project management packages.*

- *Choosing Software*

When choosing project management software, the potential user should read several software surveys conducted with project managers.

The following characteristics of generally desirable attributes in project management software are based on a number of user surveys and the comments of experienced project managers.

- **Friendliness.** For the novice user, this includes clear and logical manual, help screens, tutorials, a menu-driven structure, easy editing, and so on.

- **Schedules.** Gantt charts are mandatory, as well as automatic recalculation with updates of times, costs, and resources. Plots of earliest start, scheduled start, slack/float, latest finish, planned finish, and actual finish times are desirable. The software should also be able to display PERT ICPM networks. The time units for schedule display (and resource usage) should vary from minutes to months. The ability to handle three-time schedule inputs is desirable.

- **Calendars.** Either a job shop and/or calendar dates are necessary, plus the ability to indicate working days, non-working days, and holidays for each resource used.

- **Budgets.** The ability to include a budget for planning, monitoring, and control. Especially desirable is the ability to interface this with a spreadsheet program.

- **Reports.** Individualizing report formats is most desirable. Again, having the ability to interface the reports with a word processing package is highly desirable.

- **Graphics.** The ability to see the schedule and interactions is especially important. For Gantt charts, the software should be able to show the technical dependencies between work units or tasks.

- **Charts.** Charts for responsibility and histograms for resources were deemed particularly useful.

- **Migration.** The ability to transfer data to and from spreadsheets, word processors, database programs, graphics programs, and desired add-on programs. The ability to interface with telecommunication systems and the Internet is required for most applications.

- **Consolidation.** The ability to aggregate multiple projects into a single database for determination of total resource usage and detection of resource conflicts. The software must have the ability to recalculate all schedules and resource records when updated information is added.

A general project management information system selection process roughly based on:

1. Establish a comprehensive set of selection criteria, considering capabilities in project planning, resource management, tracking/monitoring, report generation, earned value/variance analysis, risk management.

2. Set priorities for the criteria, separating "must have" items from "nice to have" items and "not needed" items.

3. Conduct a preliminary evaluation of the software packages relative to the criteria using vendor-supplied data, product reviews, and software surveys.

4. Limit the candidate packages to three and obtain demos of each, evaluating the vendors at the same time in terms of interest, software maintenance, and support.

5. Evaluate each package with a standard project typical of your current and projected future needs. Make note of any weaknesses or strengths that are particularly relevant to your situation.

6. Negotiate on price, particularly if you are making a volume purchase or contemplating a site license. Include descriptions of vendor support, training, and product maintenance in the contract.

Chapter 3

The Existing Project Control System

3.1 Introduction

In this chapter, the existing project control system of the interior decoration company will be briefly discussed. After making the contract, three main methods will be applied to plan and control the project. They are:

1. Gantt chart
2. Site Controlling
3. Account book tracking

3.2 Gantt Chart

After making the contract, a bar chart or Gantt chart will be developed manually by the assigned project manager in the company foam to schedule the project as figure 3-1. This bar chart is quite easy to be read and interpreted by the company's subcontractors and other involved group. It is the most simple planning and scheduling technique.

Activity	Time (Weeks)									
	1	2	3	4	5	6	7	8	9	10
Prepare Material										
Ceiling Work										
Cement Work										
Wood Work										

Figure 3-1: The example of bar chart

However, as mentioned in chapter 1, in small project, this chart could, although, be used to plan and control project, efficiently, but it is rather unsuitable to be applied in

medium and big projects that have much more complexity. In such projects, more accurate information is required. Relation among these jobs cannot be shown in Gantt chart. And the following questions could not be answered:

1. What parts of these jobs can be done concurrently?

2. What parts of each job must be completed before other parts begin?

3. Must certain jobs or parts of jobs be given priority so as not to hold up scheduled completion of the project?

4. Do some jobs or parts of these jobs have optional starting an end dates, and what, specifically, are these optional dates?

Moreover, since the Gantt chart used in the company was developed manually in the paper-based system, it is also not flexible enough to be used to control projects that have frequent change in the project plan like the interior decoration project. And it is also hard to track the project progress since it is the manual paper-based Gantt chart.

From the observation, normally, the bar chart would be developed in the beginning stage of the project, and then it would be steeped in the project paper-based file. Neither revision nor much usage to control the project was occurred to that Gantt chart. The question for this is “Why did the project manager not update the project plan? The answer is we did not have any time to do it. Again, the question is “So, how can the project manager control or track the project if there are the changes due to the customer requirement?” The answer is that they are all in the project manager’s head.

As a result of the concept “The plan is in my head”, the coordination among other departments is poor. Many times, the project managers will lack the coordination with the procurement and financial department. As a result of the unclear or informal plan, the material plan and the manpower plan developed after making the contract are unreliable. Many materials have unclear needed time. They depend on the project manager. Normally, the project manager tends to stock all material at the beginning stage of the project in order to have the materials as soon as possible when they are needed. This causes the high inventory cost leading to the problems with the financial department that must allocate the company budgets to the project. Whereas, sometime, there may be a sudden need in the material items. Consequently, the procurement will have no much time to procure the material in a considerable price, and, in some cases, the budget is also not allocated enough to procure this material item at the order time. This can lead to the lack of liquidity. Moreover, in the worst case, the sudden need was not true. It was ordered to be stocked. As a result, the procurement department, sometime, do not believe when the project manager needs some material in hurry. All of these situations are, mainly caused by the unclear plan in the project manager’s head.

3.3 Site Controlling

After making the contract, a project manager will be assigned to take care the site. Planning the project, controlling the subcontractors, and reporting the project progress will be the responsibility of this project manager. With the concept of "The plan is in my head" mentioned before, the performance of site controlling tends to depend on the project manager's skill and experience. It depends on the individual more than the methods or plan. Overtime consideration and manpower addition are all depend on the project manager decision. Which activity should be crashed or more critical is determined in his mind. In addition, without any standard, the overall progress of the project is also judged by the project manager.

When the project tends to delay, many project activities will be crashed under the project manager's consideration. Many times, this leads to the unnecessarily accelerated or crashed activities. The unnecessarily crashed activities are the activities that are, although, not the critical activities, they are also crashed by the project manager in order to finish the project on time. In fact, these activities may have some float time. There are low effects in crashing the project provided by crashing the unnecessarily crashed activities. As a result of many unnecessarily crashed activities, there will be low efficiency and effectiveness in crashing the project. More costs will be charged in crashing the project on time; whereas, the project may be delay due to not enough resources allocated to crash the critical activities.

3.4 Account Book Tracking

A method that the company uses to control the project is account book tracking. The principle of it is to compare the progress of the overall project to the proportion of the operating day to the total project duration and to compare the actual expense to the estimated budget during the time. The example format used in this method can be illustrated in the conclusion form of estimated and actual expenses as shown in figure 3-2.

Although, this method is an efficient tool to compare the information numerically and to force the project control efficiently. It also has weaknesses as follows:

1. It can be done only in an accounting audit period. Many times, the data are not updated when accounting book tracking is activated.

2. The progress of the overall project also depends on the individual's judgment. It may not reflect the actual progress of the project and each activity.

3. The relation of the planned project progress to the time may be not a straight line. The example can be seen as the relation of the planed progress to the time of the case study project in chapter 6.

4. No any records illustrate performances about the subcontractors and the costs of each activity. To know why the project delays, only the project manager can be assumed. He may say, "It is because of subcontractors. They do not allocate

enough workers to finish the project on time" But how many workers was, there was no record.

Payment

Description	Value	%
Total Wages According the Contract		
(Less) Paid Wage		
Balance		
(Less) Total expense INV.		
Total Balance		

Total value		Baht
Progress		%
Actual Expense		Baht
Project Duration		Days
Operating Days		Days

Expenses Conclusion

Description	Total estimation	Actual	%	Note
Total				

Figure 3-2: The conclusion form of estimated and actual expenses

3.5 Discussion

From all mentioned in this chapter, it could be concluded that the existing control system of the company mainly depends on the individuals, project managers. The plan is always in their heads. The main reason leading to this is the paper-based control system of the company. It is rather a rigid system. The change or updating is rather difficult and consumes an amount of time. As a result, informal methods are applied automatically. These lead to the lack of coordination among the involved groups, the subcontractors, the procurement, and financial department. Consequently, the project controlling is poor due to the unclear agreements and the same commitments. Finally, the project will fail or delay. The more complexity of the project, the more effect of this cause will be.

Chapter 4

The Proposed Project Control System

4.1 Introduction

From the previous chapter, to improve the project control system, the network analysis technique should be applied in the computer-based system in order to have more flexibility system. However, because the existing system is the traditional paper-based system, the application of the full computer-based system, suddenly, will lead to the high risk to failure by the human factor. Thus, in this thesis, the network analysis technique will be applied to improve the project control system in semi-computer based manner. A project management software, Microsoft's Project 98 (MP98), will be applied in this improvement since this software was already installed on the computers of the company. Despite of the MP98 installation, there is no significant usage of this application because of three principal reasons:

1. The software does not support Thai language. There will be many errors occurring if the program default font is changed into Thai language.

2. The project managers and workforces are not used to using the format of this program. They are used to using the traditional bar chart written by hand.

3. There are low understands about the application.

In this chapter, there are two main parts. First, the activity network of the interior decoration project will be first examined. And then, the proposed planning and control procedures will be introduced.

4.2 The Activity Network of the Interior Decoration Project

From the observation, basically, the interior decoration project will, briefly, consist of activities and precedences as shown in the table 4-1. And, from the table 4-1, the activity network could be illustrated in figure 4-1 in AOA (activity-on-arrow) format. From the network, it can be seen that the interior decoration project has basically the top-down operation, finishing the works from the ceiling to the floor. The main reason for this is to not make the damage to the floor. Otherwise, reworks or added work, floor protection, will occur.

Actually, in many projects, the network can be different among the project. In the small projects, there can be fewer activities than the illustrated network in the figure 4-1. The utility system installation may not be needed. There may be only the built-in furniture installation. Whereas, in the big projects, each activities can be divided into more details than the table 4-1. Each activity in the table 4-1 can have lead-time relation

with other activities. There can be a considerably big project whose network consists of many basic networks in many areas. However, the network of each project will be different with one another, its each activity can be classified into the basic activities as shown in the table 4-1. Moreover, most projects tend to have the top-down operations if it is possible. The network as shown in the figure 4-1 can be applied as a template for the interior decoration project.

ID	Activity	Predecessors
1	Clearing the project site	-
2	Preparing build-in furniture	-
3	Producing loose furniture	-
4	Installing the electricity system	1
5	Installing the air condition system	1
6	Installing the water-supply system	1
7	Installing walls	4,5,6
8	Installing ceilings	4,5,6
9	Inspecting the site dimension and adjust the built-in furniture	7,8
10	Paving floor tiles or decorating the floor	7,8
11	Installing the built-in furniture	2,9,10
12	Painting	11
13	Install utility equipment, mirror, and etc.	12
14	Cleaning the site and installing the loose furniture	3,13
15	The customer inspection	14

Table 4-1: The activities and the predecessors in the typical interior decoration project

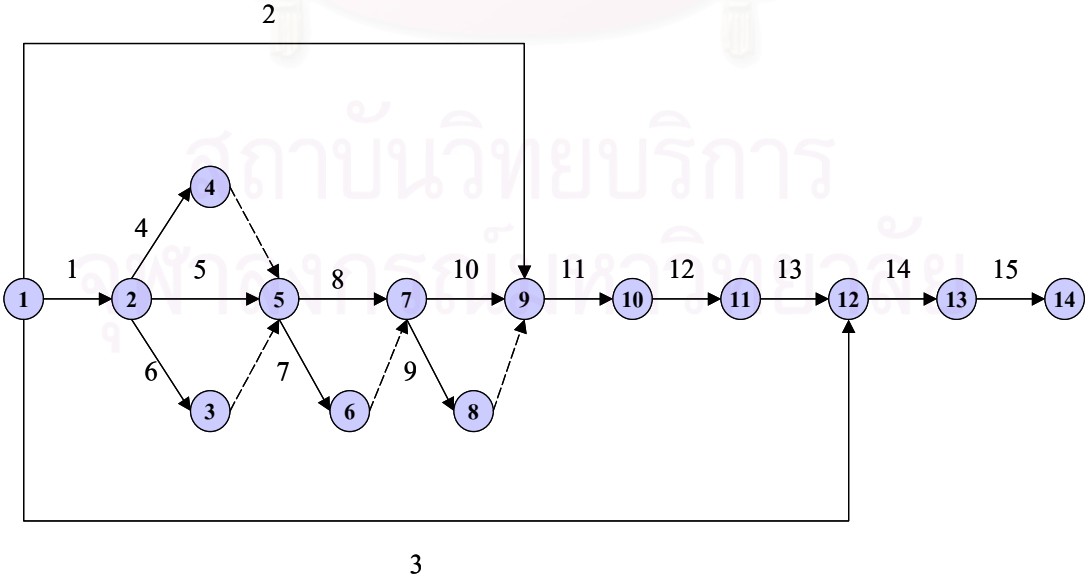


Figure 4-1: The activity network of the typical interior decoration project in AOA format

4.3 The Proposed Planning and Control Procedures

In planning and controlling the project by applying the network analysis, four stages are introduced here in the closed loop feedback control system as figure 4-2.

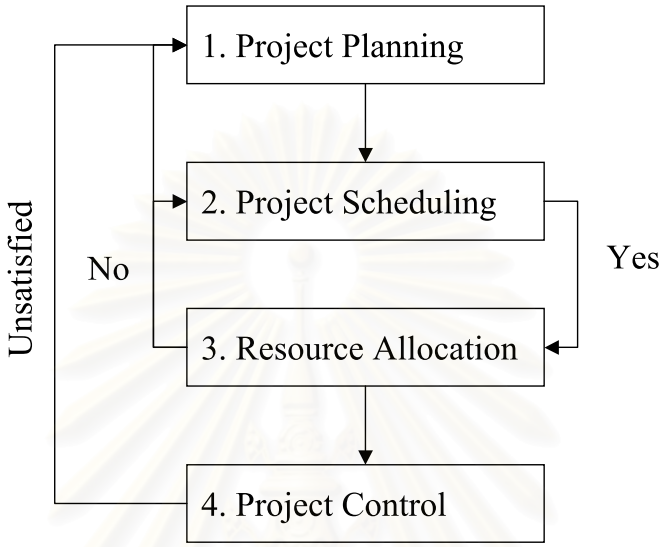


Figure 4-2: Four steps in the closed loop feedback system

4.3.1 Project Planning

In this stage, the project will be studied about the activities consisted in the project. In this stage, the data collection and analysis will be as following steps:

1. All activities in the project must be listed.
2. The relations and sequences among these activities must be defined.
3. The manpower that can be allocated and the duration of each activity must be estimated.
4. The activity network of the project must be developed to illustrated clear relations among activities.
5. Defining the material used in each activity.

In the planning stage, it is considered to be the most critical part of the network analysis technique. The collaboration from many involved groups is needed. Thus, the involved individual should have the basic knowledge about the network analysis technique and should have considerable experience about the planed project. Otherwise, the information will be error from the fact. To list all activities and defined its relation (step 1&2), the skilled individuals in this specific task are needed.

For the step 1, 2&3, the sheet of the action plan was developed. And the example of its usage for the interior decoration project of an office can be shown as table 4-2 as follows:

Loxley Interior Decoration Project								
ID	Activity	Duration	Precedence	Type of Subcontractor				
				Ceiling Craftman	Carpenter	Painter	Wallspaper	Others
1	Prepare the materials	10 days						
2	Site survey and potect the floor	1 day		2				
3	Install metal wall structure	3 days	2	4				
4	Install electricity system	2 days	3					2
5	Close light panel	4 days	3	2				
6	Wash the walls	2 days	5	2				
7	Install wallspaper	2 days	6,4				2	
8	Install electricity equipment	1 day	7					
9	Install the floor and ceiling skirts	3 days	5,1		2			
10	Paint the skirts	1 day	9			3		
11	Install door frames	2 days	1,5		2			
12	Install door panels	1 day	11		2			
13	Install door rim and mirror	1 day	12		2			
14	Paint the doors	2 days	13			3		
15	Cleaning the site	2 days	14,10,8					2

Table 4-2: The action plan of the example project

And the activity network in the format of AON (activity-on-node) of the example project can be constructed by MP98 as figure 4-3 as follows:

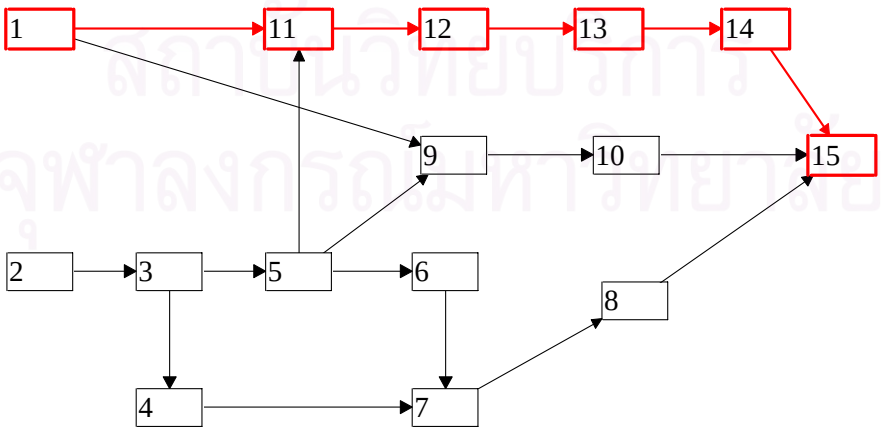


Figure 4-3: The activity network of the example project in AON format

For defining the materials used in each activity, the material check sheet was developed. But, its usage discussion will be included in the project control stage.

4.3.2 Project Scheduling

After estimating the manpower that can be allocated and the duration of each activity, the project duration can be also estimated. By the manual implementation, there will be 2 parts of computation; forward pass computation, and backward pass computation. The former will define the early start and finish date; whereas, the latter will identify the late start and finish date. As a result, the critical path of the network can be defined, and the slack and float time of each activity that is not on the critical path can be calculated. However, such calculations are rather hard to be activated manually. The more complexity of the project, the more difficulty and errors will be occurred if these calculations are prepared manually.

To ease the calculations and to have more accurate results, the application of software should be applied. For the results of project scheduling of the example project whose information is given in the table 4-2, its results of the project scheduling developed by MP98 can be illustrated as table 4-3.

ID	Task Name	Duration	Early Start	Late Start	Early Finish	Late Finish	Free Slack	Total Slack
0	Loxley Interior Decoration Project	23 days	Mon 6/5/0(	Mon 6/5/0(	Tue 6/27/0(	Tue 6/27/0(	0 days	0 days
1	Prepare the materials	15 days	Mon 6/5/0(	Mon 6/5/0(	Mon 6/19/0(	Mon 6/19/0(	0 days	0 days
2	Site survey and potect the floor	1 day	Mon 6/5/0(	Mon 6/12/0(	Mon 6/5/0(	Mon 6/12/0(	0 days	7 days
3	Install metal wall structure	3 days	Tue 6/6/0(	Tue 6/13/0(	Thu 6/8/0(	Thu 6/15/0(	0 days	7 days
4	Install electricity system	2 days	Mon 6/12/0(	Wed 6/21/0(	Tue 6/13/0(	Thu 6/22/0(	1 day	9 days
5	Close light panel	4 days	Fri 6/9/0(	Fri 6/16/0(	Mon 6/12/0(	Mon 6/19/0(	0 days	7 days
6	Wash the walls	2 days	Tue 6/13/0(	Wed 6/21/0(	Wed 6/14/0(	Thu 6/22/0(	0 days	8 days
7	Install wallspaper	2 days	Thu 6/15/0(	Fri 6/23/0(	Fri 6/16/0(	Sat 6/24/0(	0 days	8 days
8	Install electricity equipment	1 day	Sat 6/17/0(	Sun 6/25/0(	Sat 6/17/0(	Sun 6/25/0(	8 days	8 days
9	Install the floor and ceiling skirts	3 days	Tue 6/20/0(	Thu 6/22/0(	Thu 6/22/0(	Sat 6/24/0(	0 days	2 days
10	Paint the skirts	1 day	Fri 6/23/0(	Sun 6/25/0(	Fri 6/23/0(	Sun 6/25/0(	2 days	2 days
11	Install door frames	2 days	Tue 6/20/0(	Tue 6/20/0(	Wed 6/21/0(	Wed 6/21/0(	0 days	0 days
12	Install door panels	1 day	Thu 6/22/0(	Thu 6/22/0(	Thu 6/22/0(	Thu 6/22/0(	0 days	0 days
13	Install door rim and mirror	1 day	Fri 6/23/0(	Fri 6/23/0(	Fri 6/23/0(	Fri 6/23/0(	0 days	0 days
14	Paint the doors	2 days	Sat 6/24/0(	Sat 6/24/0(	Sun 6/25/0(	Sun 6/25/0(	0 days	0 days
15	Cleaning the site	2 days	Mon 6/26/0(	Mon 6/26/0(	Tue 6/27/0(	Tue 6/27/0(	0 days	0 days

Table 4-3: The results of the project scheduling of the example project

From the table 4-3, it can be seen that the project duration is 23 days, which come from the duration of the critical path. The critical path consists of activity 1, 11, 12, 13,14, and 15 (underlined), which have no both free and total slack time. To finish the project on time in 23 days, these activities must not be delay. In addition, the MP98 can also illustrates the critical path on the activity network as seen as thick lines and boxes in the figure 4-3.

4.3.3 Resource Allocation

In order to operate each activity according to the schedule developed in the project scheduling stage, there is the assumption that there are enough manpower, machine, and equipment for the needs of each activity in such period, which is not considered in the project scheduling.

To identify the possible duration of each activity, the amount of resource should be considered. Thus, the procedure may be back from the third stage to the second stage many times until the project schedule is suitable for the available resources. In some cases, it may be back to plan the project again or to the first stage. From all mentioned, it can be seen in the figure 4-2 that there was the arrow from the box of the resource allocation to both the boxes of the project planning and scheduling.

For the interior decoration company, the project operations are always outsourced to the subcontractors. The resource allocation for this thesis will be made by considering the suitable number of the subcontractors for the project from the experience of the project manager. In regardless of the experience of the project manager, the suitable number will come from the cost-effective consideration. For example, if the estimated number of the carpenters more than 5, we must hide one more group of subcontractors or let the subcontractors work overtime. This will cost the company more. Thus, the suitable number of the subcontractors will be used as the constraints in the consideration of the resource allocation.

According to the project management software, MP98, it will be used to aid constrained resource scheduling by apply Heuristic methods. Since in many cases, the interior decoration project involved with many group of subcontractors for the example in the table 4-2. It consists of 4 main subcontractor groups. Moreover, the bigger project, the more groups will involve as can be seen in the case study project in the chapter 5. For such complex and nonlinear problems of the resource, Heuristic methods are quite a reasonable choice.

From the resource leveling made by MP98, the project schedule can be seen in figure 4-4, and the estimated number of ceiling craftsmen can be displayed by the software in figure 4-5.

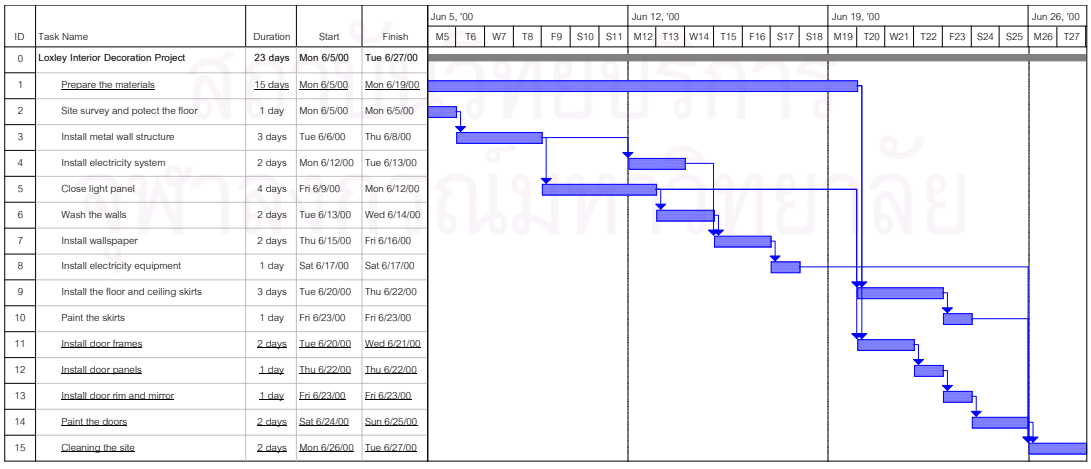


Figure 4-4: The schedule of the example project

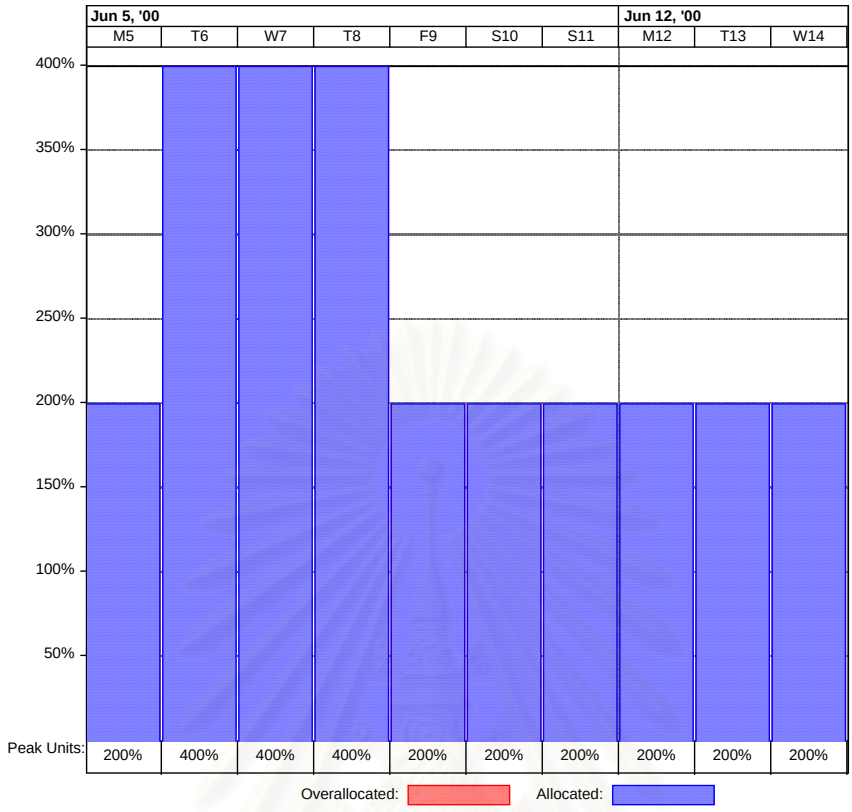


Figure 4-5: The estimated number of the ceiling craftsmen displayed by MP98

4.3.4 Project Control

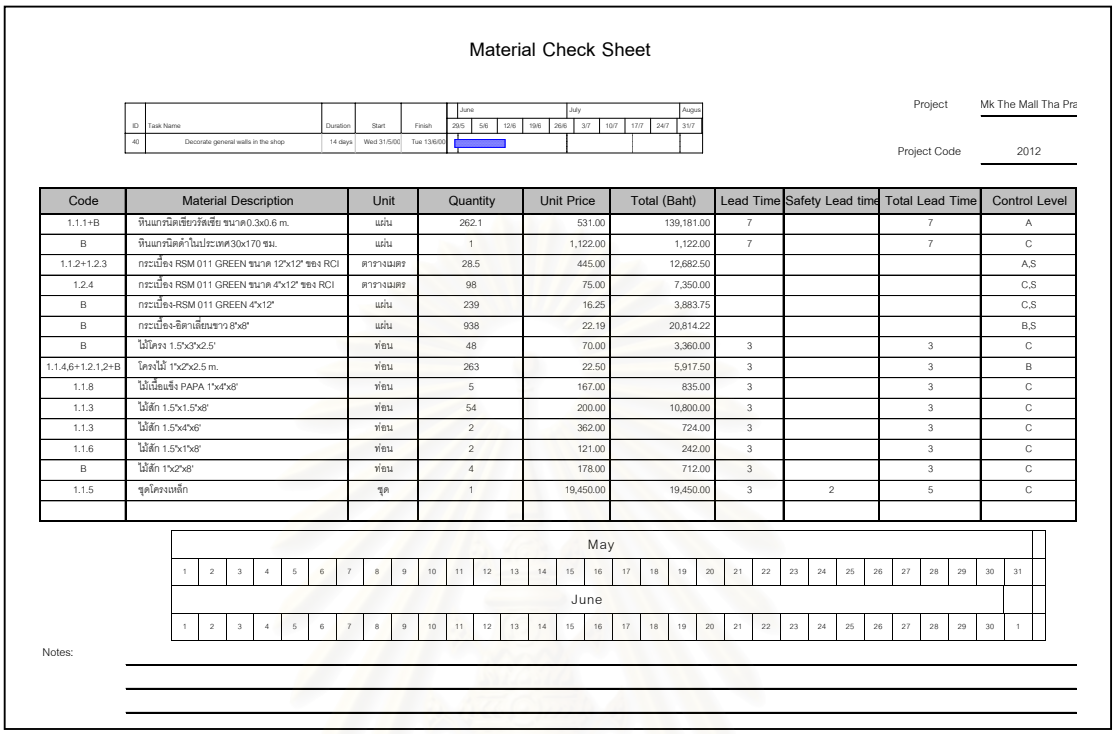
After planning the project by the network analysis and making a considerable project schedule, the project plan will be used to control the project. However, the project plan is, although, developed considerably, there can be the changes in the situation due to the new information, unforeseen problems and etc during the project duration. Thus, evaluating performance, on a regular basis, for determining what, if any, corrective action is required, and for revising schedules and the project plans accordingly. So, every stages mentioned before, project planning, project scheduling, resource allocation, and project control and tracking, will have continuous relations until the project is finished. In this thesis, three areas will be mainly controlled as follows:

1. The actual progress of the project should be tracked relating to the project plan. To finish the project on time, the critical activities must not delay.

2. The number of subcontractor at the project site should be controlled to have enough to activate the activity according to the plan.

3. The needed material and equipment should be prepared before the activity will begin.

According to the materials, the material check sheet had been developed as seen in the figure 4-6.



Material Check Sheet

ID	Task Name	Duration	Start	Finish
40	Decorate general walls in the shop	14 days	Wed 31/5/00	Tue 13/6/00

June: 29/5 5/6 12/6 19/6 26/6 — July: 3/7 10/7 17/7 24/7 — Augus: 31/7

Project: Mk The Mall Tha Pra

Project Code: 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
1.1.1+B	หินแกรนิตเขียวรัตเขียว ขนาด0.3x0.6 m.	แผ่น	262.1	531.00	139,181.00	7		7	A
B	หินแกรนิตดำในประเทศ30x170 ซม.	แผ่น	1	1,122.00	1,122.00	7		7	C
1.1.2+1.2.3	กระเบื้อง RSM 011 GREEN ขนาด 12"x12" ของ RCI	ตารางเมตร	28.5	445.00	12,682.50				A,S
1.2.4	กระเบื้อง RSM 011 GREEN ขนาด 4"x12" ของ RCI	ตารางเมตร	98	75.00	7,350.00				C,S
B	กระเบื้อง-RSM 011 GREEN 4"x12"	แผ่น	239	16.25	3,883.75				C,S
B	กระเบื้อง-อิตาเลี่ยนขาว 8"x8"	แผ่น	938	22.19	20,814.22				B,S
B	ไม้โครง 1.5"x3"x2.5'	ท่อน	48	70.00	3,360.00	3		3	C
1.1.4,6+1.2.1,2+B	โครงไม้ 1"x2"x2.5 m.	ท่อน	263	22.50	5,917.50	3		3	B
1.1.8	ไม้เนื้อแข็ง PAPA 1"x4"x8'	ท่อน	5	167.00	835.00	3		3	C
1.1.3	ไม้สัก 1.5"x1.5"x8'	ท่อน	54	200.00	10,800.00	3		3	C
1.1.3	ไม้สัก 1.5"x4"x6'	ท่อน	2	362.00	724.00	3		3	C
1.1.6	ไม้สัก 1.5"x1"x8'	ท่อน	2	121.00	242.00	3		3	C
B	ไม้สัก 1"x2"x8'	ท่อน	4	178.00	712.00	3		3	C
1.1.5	ชุดโครงเหล็ก	ชุด	1	19,450.00	19,450.00	3	2	5	C

May: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

June: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1

Notes:

Figure 4-6: The material check sheet

According to the material check sheet, it will be applied since the project planning stage. After listing all activities in the project, the materials used in each activity will be defined. The list of material items for each activity will be recorded in the material check sheets as the figure 4-6. And then, when the activity network is created by applying MP98, each activity item will be linked to the material check sheet that is created by Microsoft Excel. As a result, the material check sheet will be updated automatically when there are any changes occurring to the linked activity. Thus, if there are any changes occurring to the project schedule from the plan audit, there will be no needs to update this form, manually. The reason for this is to ease the file updating. After the resource allocation, the linked information from MP98 will make the user know when the listed item will be used. And with the information about the lead-time of each item, it also makes the user know when we should order these material items.

The time scale is attached to the material check sheet in order to ease visible check. Here, the cross mark is on the planed start date of the activity and the circle mark is on the material ordered date. Since this activity has the start date at 31/5/00 (cross mark), the ordered date for the 3-day lead-time material should be 28/5/00 (Circle mark); whereas, it is 24/5/00 for the 7-day lead-time material. Although, the last material item, normally, has 3-day lead-time. Its total value is quite high. The safety time to allocate the budget should be 2 days. Thus, the project manager should order this material to the procurement department before 26/5/00.

For the control level, it illustrates the significant level of each material to the project. The significant levels from much to less are A, B, and C, respectively. In

addition, the letter S means the procurement function of this material item was outsourced to the subcontractor.

For the project manager, the material check sheet can be used to check the availability of the material items and the considerable order time. On the other hand, it can be used to aid the budget planning of the financial department. Moreover, from the reasonable lead-time allowance and the material control level, the procurement department can make more effective decision leading to the cost effectiveness of the company. The coordination among the groups involving the project will improve.

Chapter 5

The Case Study Project

5.1 Introduction

The case study project is an interior decoration project of a restaurant, which has a lot of chains in Thailand and expects to have 100 chains before the end of year 2000. The project site is on the second-floor of an operating department store, as shown in the figure 5-1, which locates far from the interior decoration company about 22 kilometers by the distance as the crow files and about 33 kilometers by the traveling distance.

The project could be treated as a medium to a big project of the company by its value. Besides the interior decoration work, the work areas of this project also covers installing utility system, installing iron structure, laying bricks, and washing the wall. In fact, it is a small construction project involving many groups and types of subcontractors. The project duration is 75 days; whereas, the company's work area must be completed in 67 days since the rest time should be available for the inspection. In addition, about the management function, a consultant company was employed by the owner client to take care the project since the biding phase.

Figure 5-1: The operating department store and the project site

Although, the consultant company was employed and there were many groups and types of subcontractors involving the project, the major responsibility of the project is delegated to the interior decoration company. Since, the subcontractor groups of the company activated most work areas of the project such as structure work, cement work, and interior decoration, all of which absorb major costs of the project. Moreover, the quality of the interior decoration work is also the first appearance of the restaurant affecting, significantly, to the sudden success or failure of the project. The utility system was, although, designed and installed very well, and could be operated with high

reliability and safety, the quality of the project could be judged to be low or not satisfy the owner client because the quality of the color of the ceiling of the shop is poor, or there are only a few scratches on the booth or on the floor tile. In many case, the reverse is true until there will be deaths due to an electric shock, a fire, and etc. In fact, the interior decoration is rather a fussy work depending on individuals.

5.2 The Relation among other Project Groups

The relations of the interior decoration company among other groups of the project could be shown in the figure 5-2 as follows.

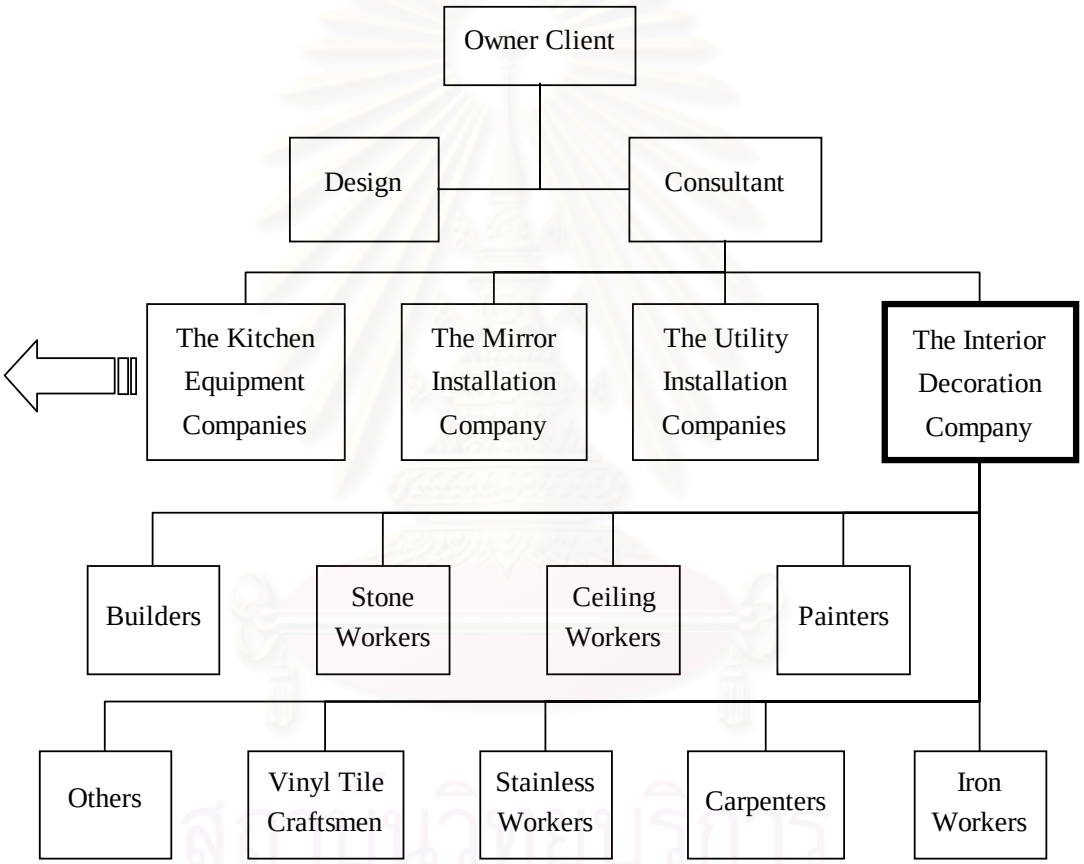


Figure 5-2: The Relations of the Interior Decoration Company among the Other Project Groups

From the figure 5-2, besides the company, there are many other groups of subcontractors involving, directly, with the consultant. And it could also be seen that the subcontractors of the interior decoration company could be grouped into 9 principal types. They are builders, stone workers, ceiling workers, painters, ironworkers, carpenters, stainless workers, vinyl tile craftsmen, and other craftsmen.

- **Builders:** The builders, mainly, consist of brick masons, tile craftsmen, and cement workers. They will be employed to place floor toping, set wall base, lay wall brick, wash wall, and pave tiles.

- **Stone workers:** The stone workers' work will be, generally, in decorating walls and partitions with granite sheets, placing terrazzo, and polishing terrazzo floor. For decorating walls and partitions, it can be activated after washing the walls or the partition with cement. Whereas, placing terrazzo and polishing terrazzo in the kitchen area must be done after laying foam and placing concrete.

- **Ceiling workers:** The responsibility of these craftsmen is, normally, to install the ceilings. They were applied to install the stud metal structure and ceiling panels. Since their works are on the ceiling, scaffolds are needed for their works.

- **Painters:** The painters will be used in decorating the color of wall, partition, ceiling, and furniture. In actual, their work, usually, starts near the end of other works. The painters will be used on the finishing stage of the project.

- **Ironworkers:** The main responsibility of the ironworkers is to install the iron structure of the mezzanine and stair. They are able to weld and cut the steel. Moreover, they were also used in installing the steel structure in the sale area around the entrance of the restaurant.

- **Carpenters:** The carpenters are the important workforces for the interior decoration activities in this project. Their skills were, mainly, used in carpentry joinery works in the decoration of walls and partitions. The carpenters were also needed in the arc ceiling installation in the sale area whose arc structure is wooden. Moreover, they were also needed in the installation of both built-in and loose furniture.

- **Stainless workers:** The stainless workers response for the stainless works used in decorating the tops of the walls and partitions and installing the furniture.

- **Vinyl tile craftsmen:** The vinyl craftsmen will be used in paving vinyl tiles at the mezzanine & stair areas.

- **Other craftsmen:** This type of the subcontractors consists of the workforces that could not be classified or grouped into the other types of the subcontractors mentioned above. Normally, they are labors and cleaners.

Besides many types of subcontractors, each type of them might have a few groups carrying out a specific work area. For example, installing the wooden structure of the ceiling may be undertaken by a group of carpenter, while installing the loose furniture may be activated by other carpenter group. However, the depth of this thesis will not include those details.

5.3 The Site Constraints

Since the project site is on the second floor of the operating department store. There are two principal constrains for this project in order to not disturb customers and other shops.

1. The loud-noise activities could not be activated during the daytime. They could be done after the close time of the department store at 10.00 pm. This, directly, affects the clearing site and the installation of iron structure at the beginning stage of the project.

2. The materials could not be delivered the site before 10.00 pm. This affects the material management in the site. If there is the lack of the material in the daytime, the material will not be able to deliver to the site. The delivery must be waited until the night. As a result, the stoppage of the work activity will be occurred, which can cause the delay of the project. Under this condition, the limitation of the site area is also an important factor. Stocking materials can cause many problems as can be seen in the following section.

Unlike other project sites of the same restaurant that the company used to undertake, they are normally on the first floor of the under constructed department store. No such limitations or constraints mentioned above occurred. Since they were on the first floor of the under constructed department store, the loud-noise activities could be activated during the daytime. Any hard or loud-noise construction equipment could be used. And materials, such as plywood, iron structure, a lot of tile boxes, and etc., could be stocked at the site area without any troubles to keep the continuality of the work activities. They could be delivered to the sites in the daytime, when they were needed. Moreover, the first floor also eases the delivery. Sometimes, the company's suppliers could deliver the materials to the work site, directly. Stocking the materials at the company's factory could be avoided. But, for this project, most materials, which were not outsourced the procurement function to the subcontractors, must be stocked at the factory.

5.4 The Consultant's Schedule

After making the contract, the consultant sent the project schedule made by applying Microsoft's Project to the company (see appendix A). And there was a kick-off meeting after sending the plan for 1 day. One interesting topic of this meeting is if the company could operate under that schedule.

In regard to the project schedule, it was made by using a project management software package, Microsoft's Project (MP). There are 125 elements on this schedule, which may be considered to be over detailed for this size of project whose area is only 410 square meters. In addition, there are three more interesting points about this schedule as follows:

1. From the data of the previous projects of the same restaurant, the given schedule is like the previous schedules used in the previous projects. The differences that can be seen, obviously, are only project name, dates, and increasing elements. The construction projects are, although, alike in nature, there are differences in details. Thus, the plan and the schedule should be varied depending on each project. In fact, each project is unique. Moreover, increasing elements can cause over detailing of the project. Over detailed plans, budgets, schedules, and control systems do not automatically equate to more successful projects. In reality, the reverse is true: overkill systems have hurt more small projects than underpowered ones have hurt large projects. Simplicity is an important factor.

2. The consultant, although, applies MP, it tends to be used to aid writing bar or Gantt chart. The relation among activities could not be presented clearly. In many previous projects, there would be some conflicts among those activities in the consultant's schedule. For example, laying bricks and washing walls in the cashier area were expected to be started when the iron structure of the mezzanine had not finished.

3. According to the data of the previous projects and this project, there will be, normally, only one project schedule given by the consultant for each project. There are no revised schedules. This illustrates that the consultant always writes the project schedule only one time before the kick-off meeting for each project. This can be assumed that this consultant almost does not revise the given plan, or the revised plan was not shown to the company.

The interesting questions for these points are "how can they control and coordinate the subcontractors involving the projects?" and "if they do not want to revise the plan, why do they ask us if we can operate under the given schedule?" An experienced project manager of the company gave comments about these questions. He said, "This consultant is stubborn. When they want to do, we must do it without notices. They act as an inspector rather than a coordinator. The project plan is in their heads. Actually, we could not operate activities on time given in the consultant's schedule".

5.5 The Proposed Plan of the Case Study Project

5.5.1 The Action Plan

By considering the consultant's schedule and the comments from the project manager who has experience about this type of project, the action plan and the activity network of the project in AON format can be illustrated as table 5-1 and figure 5-3 respectively. The action plan contains the information we need to apply the network analysis technique. It is a list of all activities that must be undertaken in order to complete the project, the predecessor activities for each activity, the duration each activity is expected to take, and the number and types of workforces in each activity. However, due to the lack of information about activities those are not undertaken by the company, this action plan was developed by the viewpoint of the interior decoration company. And the number of workforces was estimated only for the activities at the project site.

ID	Activities	Duration	Precedence	Builder	Stone Worker	Ceiling Worker	Painter	Ironworker	Carpenter	Stainless Worker	Vinyl Craftsman	Others
	General works											
1	Clear ceiling	8 days										6
2	Clear sale area & install intercepting partitions	6 days										6
3	Clear kitchen area	8 days	2									7
4	Layout & get permission	8 days	2									
	Mezzanine & stair works											
5	Install mezzanine and stair main structure	8 days	3,4					7				
6	Finish mezzanine structure	10 days	5					7				
7	Install utility system in the mezzanine area	7 days	6									
8	Install light partition, wash, and paint in the mezzanine area	7 days	7			2	2					
9	Pave vinyl tiles at the mezzanine&stair area	1 day	8								4	
	Kitchen area works											
10	Install utility system at kitchen area	20 days	1									
11	Set wall base in the kitchen area	2 days	3,4	5								
12	Water test, permeating protection, and install gutter	7 days	11	2								
13	Lay wall bricks, and wash walls in the kitchen area	8 days	5,11	5								
14	Pave wall tiles in the kitchen area	7 days	13	4								
15	Lay foam and place concrete	2 days	12,14	5								
16	Place terrazzo and polish terrazzo	7 days	15		4							
17	Paint and trim in the kitchen area	3 days	16				2					
18	Install kitchen ceiling	4 days	10,17			2						4
19	Install kitchen equipment	4 days	8,18						2			
	Cashier area works											
20	Prepare built-in furniture in the cashier area	14 days										
21	Install utility system in the cashier area	14 days	1									
22	Lay wall bricks, wash, and pave wall tiles in the cashier area	5 days	5	3								
23	Pave ground tiles in the cashier area	3 days	22	2								
24	Install cashier ceiling	1 day	21,23			2						
25	Install built-in furniture in the cashier area	3 days	20,24		2				3			
26	Paint and trim in the cashier area	1 day	25				2					
	Sale area works											
27	Prepare built-in furniture in the sale area	21 days										
28	Install utility systems in the sale area	16 days	1									
29	Install ground electricity system	5 days	4									
30	Install partitions in the sale area	7 days	29	9								
31	Place toping and pave ground tiles in the sale area	5 days	30	6								
32	Install ceiling in the sale area	19 days	28,31			5			4			
33	Decorate partitions	14 days	31	4	4				5			
34	Install built-in furniture in the sale area	5 days	27,33						7			
35	Decorate general walls in the shop	14 days	31	5	5		6		5	5		
36	Wash and paint ceiling in the sale area	3 days	32,34,35				4					
37	Finish color in the site	4 days	36				4					
	Loose furniture											
38	Send samples of loose furniture	10 days										
39	Assemble loose furniture at the factory	21 days	38									
40	Install loose furniture	4 days	9,26,37,39						7			
	Door works											
41	Prepare the panels of doors	7 days										
42	Install doors and equipment	2 days	19,40,41						4			
43	COMMISSIONING & TEST RUN	2 days	42									
44	Clean the site	2 days	43									10

Table 5-1: The action plan of the case study project

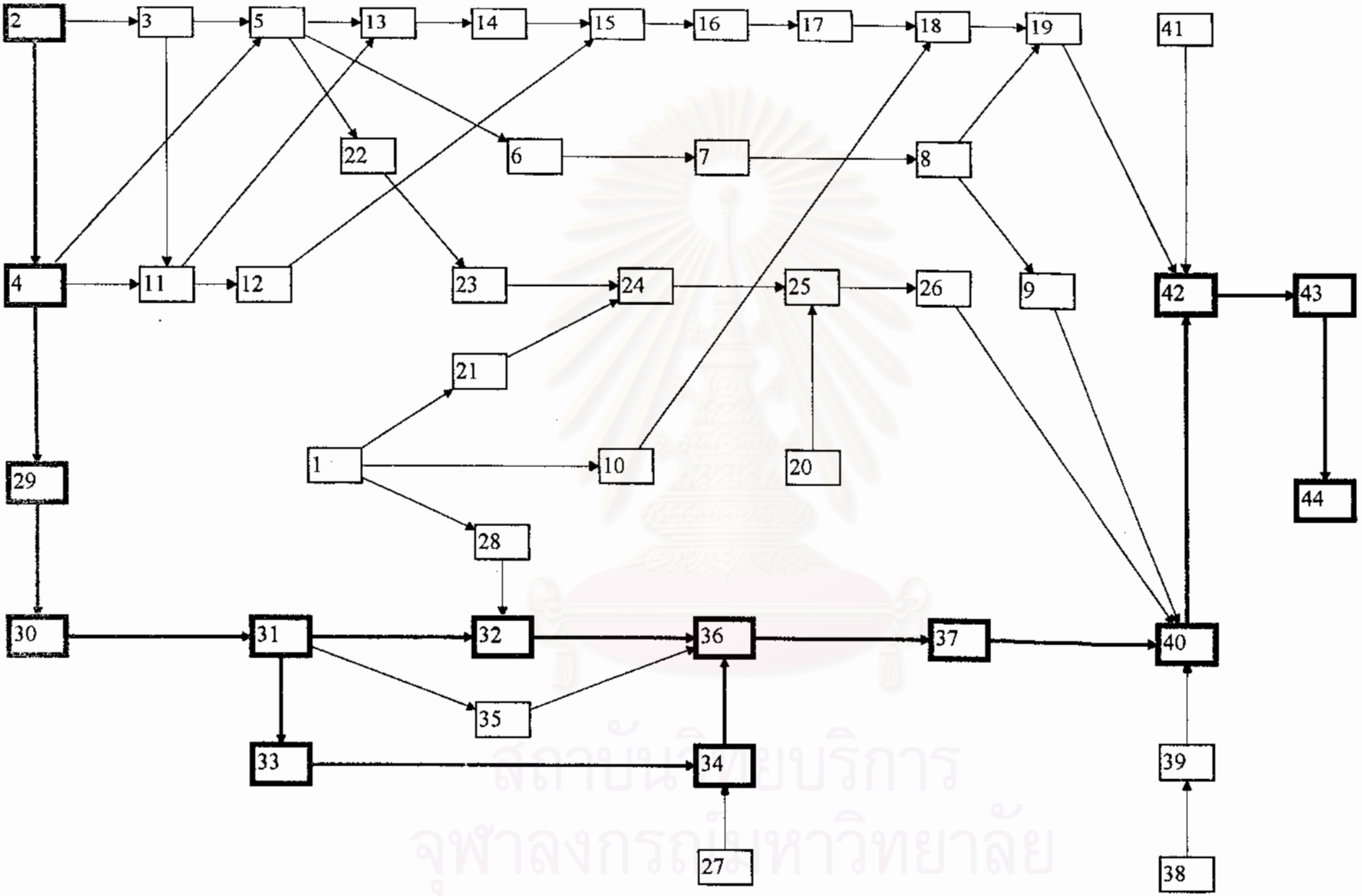


Figure 5-3: The activity network of the project in AON format

From the action plan in the table 5-1, the activities can be classified into 7 main groups. They are general works, mezzanine & stair works, kitchen area works, cashier area works, sale area works, loose furniture, and door works, those of which must be activated before commissioning & test run and cleaning the site. The general works will include clearing the site and making layout. Those activities must be done before other activities. The following four activity groups, the mezzanine & stair works, the kitchen area works, the cashier area works, and the sale area works, are divided by the areas of the restaurant. These four areas could be divided clearly by considering the different ceiling types used in each area as can be seen in the design drawing of the project (see in appendix B). CL-1, CL-2, and CL-3 are the ceiling types of the sales area. CL-3A is the ceiling type of the cashier area. And CL-5 and CL-6 are the ceiling types of the kitchen area; whereas, CL-7 is the ceiling type of the mezzanine & stair area locating above the cashier and kitchen areas. The loose furniture activities are sending samples, assembling loose furniture, and Install loose furniture at the project site. The former two activities must be done at the factory of the company; whereas, the latter, installing loose furniture, must be operated at the project site. The door works consist of two activities, preparing the panels of the doors, and installing doors & equipment.

In regard to the activity network of the project, there are 14 critical activities of total 44 activities, or about 32% of total activities. The critical activities (thick boxes) are activities 2, 4, 29, 30, 31, 32, 33, 34, 36, 37, 40, 42, 43, and 44, which cause the longest total duration, 67 days. It could be seen that the critical path is mainly on the sales area works, whose activities are activities 29, 30, 31, 32, 33, 34, 36, and 37, or about 57% of the total number of critical activities. These critical activities should be controlled, strictly, to start and finish on the planed time. Otherwise, it will cause the delay of the project, or the actual project duration will exceed 67 days.

From the activities network, unlike other interior decoration projects, this project has down-top operations. Since it can be seen that the activities of paving tiles precedes the activities of installing ceiling in all areas but the mezzanine & stair area that applies vinyl tiles and has normal top-down operation. This, obviously, causes reworks due to the damage of floor caused by installing ceiling. However, there are five reasons given by the project manager to support why the down-top operation is a more considerable choice than the normal top-down operation.

1. If we do the top-down operation or wait until installing the ceiling is finished, and then begin to decorate the floor, it will take much more duration that will not satisfy the consultant.

2. We can protect the floor when we install the ceiling. Thus, not too much damage will occur to the floor.

3. The added labor costs caused by the reworks are not our responsibility. They are all our subcontractors' responsibility. We outsource the operations to them.

4. Paving tiles will make the site environment be clear, as a result, the project progress will increase faster.

5. For this type of project, we used to expect to install the ceiling before pave tiles. But it never occurs.

5.5.2 The Project Schedule and Manpower Plan

After making the network analysis, the project schedule in bar chart had been developed by applying Microsoft's Project 98. The project had begun since Friday 28 April 2000. In developing the project schedule, resource leveling has been done under the constraints in the available number of each subcontractor type by considering the project size as follows:

1. Builders should not exceed 15 workers.
2. Stone workers should not exceed 13 workers.
3. Ceiling workers should not exceed 7 workers.
4. Painters should not exceed 8 workers.
5. Ironworkers should not exceed 7 workers.
6. Carpenters should not exceed 16 workers.
7. Stainless workers are about 5 workers.
8. Vinyl tile craftsmen are about 4 workers.

In addition, the total workers in each day should be minimized due to the limitation area of the project site. By the business nature, everyday are working time. However, in this project, there is a holiday, which is the Labor Day on May 1. The project schedule and the estimated number of required workforces in each day can be shown in figure 5-4 and table 5-2 consecutively. And the information about early start, latest start, early finish, late finish, free slack, and total slack for each activity can be seen in table 5-3.

ID	Task Name	Duration	Start	Finish
0	**Mk The Mall Tha Pra**	**67 days**	**Fri 4/28/00**	**Tue 7/4/00**
1	Clear ceiling	8 days	Fri 5/5/00	Fri 5/12/00
2	Clear sale area & install intercepting partitions	6 days	Fri 4/28/00	Thu 5/4/00
3	Clear kitchen area	8 days	Fri 5/5/00	Fri 5/12/00
4	Layout & get permission	8 days	Fri 5/5/00	Fri 5/12/00
5	Install mezzanine and stair main structure	8 days	Sat 5/13/00	Sat 5/20/00
6	Finish mezzanine structure	10 days	Sun 5/21/00	Tue 5/30/00
7	Install utility system in the mezzanine area	7 days	Wed 5/31/00	Tue 6/6/00
8	Install light partition, wash, and paint in the mazzar	7 days	Tue 6/13/00	Mon 6/19/00
9	Pave vinyl tiles at the mazzanine&stair area	1 day	Tue 6/20/00	Tue 6/20/00
10	Install utility system at kitchen area	20 days	Sat 5/13/00	Thu 6/1/00
11	Set wall base in the kitchen area	2 days	Sat 5/13/00	Sun 5/14/00
12	Water test, permeating protection, and install gutte	7 days	Mon 5/15/00	Sun 5/21/00
13	Lay wall bricks, and wash walls in the kitchen area	8 days	Mon 5/22/00	Mon 5/29/00
14	Pave wall tiles in the kitchen area	7 days	Tue 5/30/00	Mon 6/5/00
15	Lay foam and place concrete	2 days	Tue 6/6/00	Wed 6/7/00
16	Place terrazzo and polish terrazzo	7 days	Thu 6/8/00	Wed 6/14/00
17	Paint and trim in the kitchen area	3 days	Thu 6/15/00	Sat 6/17/00
18	Install kitchen ceiling	4 days	Sun 6/18/00	Wed 6/21/00
19	Install kitchen equipment	4 days	Thu 6/22/00	Sun 6/25/00
20	Prepare built-in furnitures in the cashier area	14 days	Mon 5/15/00	Sun 5/28/00
21	Install utility system in the cashier area	14 days	Sat 5/13/00	Fri 5/26/00
22	Lay wall bricks, wash, and pave wall tiles in the ca	5 days	Thu 5/25/00	Mon 5/29/00
23	Pave ground tiles in the cashier area	3 days	Tue 6/13/00	Thu 6/15/00
24	Install cashier ceiling	1 day	Sun 6/18/00	Sun 6/18/00
25	Install built-in furniture in the cashier area	3 days	Mon 6/19/00	Wed 6/21/00
26	Paint and trim in the cashier area	1 day	Thu 6/22/00	Thu 6/22/00
27	Prepare built-in furniture in the sale area	21 days	Mon 5/15/00	Sun 6/4/00
28	Install utility systems in the sale area	16 days	Sat 5/13/00	Sun 5/28/00
29	Install ground electricity system	5 days	Sat 5/13/00	Wed 5/17/00
30	Install partitions in the sale area	7 days	Thu 5/18/00	Wed 5/24/00
31	Place toping and pave ground tiles in the sale area	5 days	Thu 5/25/00	Mon 5/29/00
32	Install ceiling in the sale area	19 days	Tue 5/30/00	Sat 6/17/00
33	Decorate partitions	14 days	Tue 5/30/00	Mon 6/12/00
34	Install built-in furniture in the sale area	5 days	Tue 6/13/00	Sat 6/17/00
35	Decorate general walls in the shop	14 days	Wed 5/31/00	Tue 6/13/00
36	Wash and paint ceiling in the sale area	3 days	Sun 6/18/00	Tue 6/20/00
37	Finish color in the shop	4 days	Wed 6/21/00	Sat 6/24/00
38	Send samples of loose furnitures	10 days	Fri 4/28/00	Mon 5/8/00
39	Assembly loose furnitures at the factory	21 days	Tue 5/23/00	Mon 6/12/00
40	Install loose furnitures	4 days	Sun 6/25/00	Wed 6/28/00
41	Prepare the panel of doors	7 days	Sun 6/18/00	Sat 6/24/00
42	Install doors and equipment	2 days	Thu 6/29/00	Fri 6/30/00
43	COMMISSIONING & TEST RUN	2 days	Sat 7/1/00	Sun 7/2/00
44	Clean the site	2 days	Mon 7/3/00	Tue 7/4/00

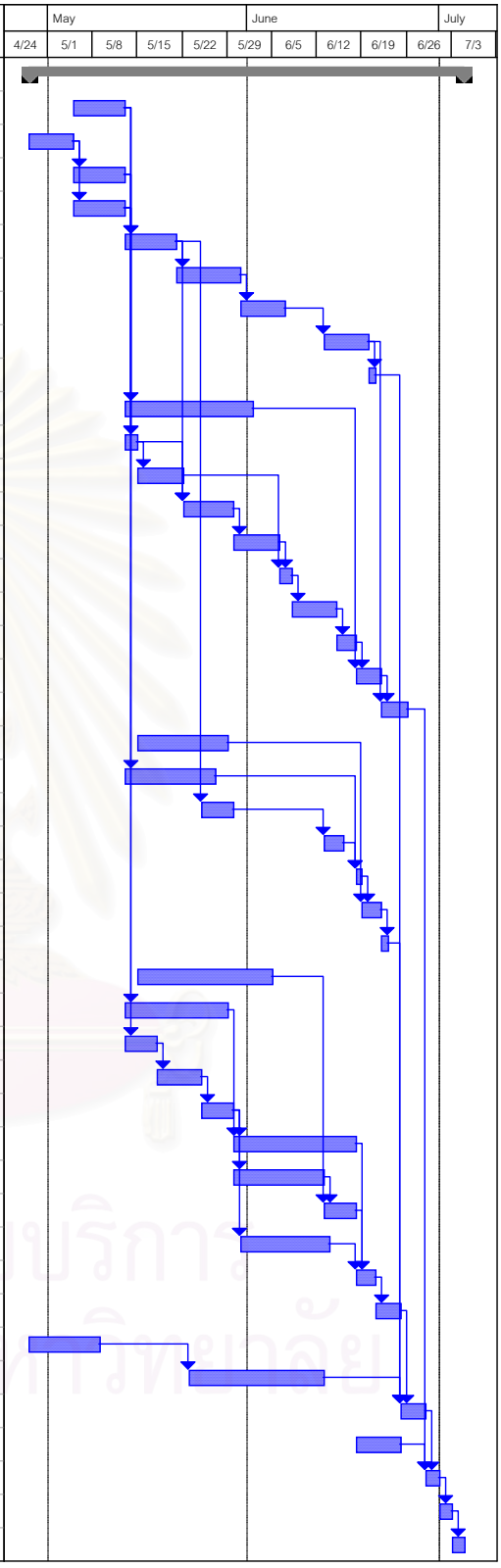


Figure 5-4: The project schedule in bar chart

Number of labors

Type	เม.ย.-00			พ.ค.-00																														
	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Builders																5	5	2	2	2	11	11	11	11	14	14	14	14	14	14	14	14	8	13
Stone workers																																	4	9
Ceiling workers																																	5	5
Painters																																	6	6
Ironworkers																7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	
Carpenters																																	9	14
Stainless Workers																																		5
Vinyl Tile Craftsmen																																		
Others	6	6	6		6	6	6	13	13	13	13	13	13	13	13																			
Totals	6	6	6		6	6	6	13	13	13	13	13	13	13	13	12	12	9	9	9	18	18	18	18	21	21	21	21	21	21	21	21	39	52

Number of labors

Type	มิ.ย.-00																														ก.ค.-00			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4
Builders	13	13	13	13	13	14	14	9	9	9	9	9	7	2	2																			
Stone workers	9	9	9	9	9	9	9	13	13	13	13	13	9	4					2	2	2													
Ceiling workers	5	5	5	5	5	5	5	5	5	5	5	5	7	7	7	7	7	6	4	2	2													
Painters	6	6	6	6	6	6	6	6	6	6	6	6	8	2	4	4	4	6	6	4	4	6	4	4										
Ironworkers																																		
Carpenters	14	14	14	14	14	14	14	14	14	14	14	14	16	11	11	11	11		3	3	3	2	2	2	9	7	7	7	4	4				
Stainless Workers	5	5	5	5	5	5	5	5	5	5	5	5	5																					
Vinyl Tile Craftsmen																				4														
Others																		4	4	4	4												10	10
Totals	52	52	52	52	52	53	53	52	52	52	52	52	52	26	24	24	22	16	19	19	15	8	6	6	9	7	7	7	4	4	0	0	10	10

Table 5-2: The manpower plan

ID	Task Name	Duration	Start	Finish	Early Start	Late Start	Early Finish	Late Finish	Free Slack	Total Slack
0	Mk The Mall Tha Pra	87 days	Fri 4/28/00	Tue 7/4/00	Fri 4/28/00	Fri 4/28/00	Tue 7/4/00	Tue 7/4/00	0 days	0 days
1	Clear ceiling	8 days	Fri 5/5/00	Fri 5/12/00	Fri 5/5/00	Sat 5/6/00	Fri 5/12/00	Sat 5/13/00	0 days	1 day
2	Clear sale area & install interceptino partitions	5 days	Fri 4/28/00	Thu 5/4/00	Fri 4/28/00	Fri 4/28/00	Thu 5/4/00	Thu 5/4/00	0 days	0 days
3	Clear kitchen area	8 days	Fri 5/5/00	Fri 5/12/00	Fri 5/5/00	Sun 5/7/00	Fri 5/12/00	Sun 5/14/00	0 days	2 days
4	Layout & get permission	8 days	Fri 5/5/00	Fri 5/12/00	Fri 5/5/00	Fri 5/5/00	Fri 5/12/00	Fri 5/12/00	0 days	0 days
5	Install mezzanine and stair main structure	8 days	Sat 5/13/00	Sat 5/20/00	Sat 5/13/00	Mon 5/15/00	Sat 5/20/00	Mon 5/22/00	0 days	2 days
6	Finish mezzanine structure	10 days	Sun 5/21/00	Tue 5/30/00	Sun 5/21/00	Thu 5/25/00	Tue 5/30/00	Sat 6/3/00	0 days	4 days
7	Install utility system in the mezzanine area	7 days	Wed 5/31/00	Tue 6/6/00	Wed 5/31/00	Sun 6/4/00	Tue 6/6/00	Sat 6/10/00	0 days	4 days
8	Install light partition, wash, and paint in the mezzanine area	7 days	Tue 6/13/00	Mon 6/19/00	Wed 6/7/00	Sat 6/17/00	Mon 6/19/00	Fri 6/23/00	0 days	4 days
9	Pave vinyl tiles at the mezzanine&stair area	1 day	Tue 6/20/00	Tue 6/20/00	Tue 6/20/00	Sat 6/24/00	Tue 6/20/00	Sat 6/24/00	4 days	4 days
10	Install utility system at kitchen area	20 days	Sat 5/13/00	Thu 6/1/00	Sat 5/13/00	Thu 6/1/00	Thu 6/1/00	Tue 6/20/00	15 days	19 days
11	Set wall base in the kitchen area	2 days	Sat 5/13/00	Sun 5/14/00	Sat 5/13/00	Mon 5/22/00	Sun 5/14/00	Tue 5/23/00	8 days	9 days
12	Water test, permeating protection, and install gutter	7 days	Mon 5/15/00	Sun 5/21/00	Mon 5/15/00	Fri 5/2/00	Sun 5/21/00	Thu 6/3/00	15 days	18 days
13	Lay wall bricks, and wash walls in the kitchen area	8 days	Mon 5/22/00	Mon 5/29/00	Sun 5/21/00	Thu 5/25/00	Mon 5/29/00	Thu 6/1/00	0 days	3 days
14	Pave wall tiles in the kitchen area	7 days	Tue 5/30/00	Mon 6/5/00	Tue 5/30/00	Fri 6/2/00	Mon 6/5/00	Thu 6/8/00	0 days	3 days
15	Lay foam and place concrete	2 days	Tue 6/6/00	Wed 6/7/00	Tue 6/6/00	Fri 6/9/00	Wed 6/7/00	Sat 6/10/00	0 days	3 days
16	Place terrazzo and polish terrazzo	7 days	Thu 6/8/00	Wed 6/14/00	Thu 6/8/00	Sun 6/11/00	Wed 6/14/00	Sat 6/17/00	0 days	3 days
17	Paint and trim in the kitchen area	3 days	Thu 6/15/00	Sat 6/17/00	Thu 6/15/00	Sun 6/18/00	Sat 6/17/00	Tue 6/20/00	0 days	3 days
18	Install kitchen ceiling	4 days	Sun 6/18/00	Wed 6/21/00	Sun 6/18/00	Wed 6/21/00	Wed 6/21/00	Sat 6/24/00	0 days	3 days
19	Install kitchen equipment	4 days	Thu 6/22/00	Sun 6/25/00	Thu 6/22/00	Sun 6/25/00	Sun 6/25/00	Wed 6/28/00	3 days	3 days
20	Prepare built-in furnitures in the cashier area	14 days	Mon 5/15/00	Sun 5/28/00	Mon 5/15/00	Wed 6/7/00	Sun 5/28/00	Tue 6/20/00	21 days	23 days
21	Install utility system in the cashier area	14 days	Sat 5/13/00	Fri 5/26/00	Sat 5/13/00	Sun 6/4/00	Fri 5/26/00	Sat 6/17/00	20 days	22 days
22	Lay wall bricks, wash, and pave wall tiles in the cashier area	5 days	Thu 5/25/00	Mon 5/29/00	Sun 5/21/00	Sat 5/27/00	Mon 5/29/00	Wed 5/31/00	0 days	2 days
23	Pave ground tiles in the cashier area	3 days	Tue 6/13/00	Thu 6/15/00	Tue 5/30/00	Thu 6/15/00	Thu 6/15/00	Sat 6/17/00	0 days	2 days
24	Install cashier ceiling	1 day	Sun 6/18/00	Sun 6/18/00	Fri 6/16/00	Tue 6/20/00	Sun 6/18/00	Tue 6/20/00	0 days	2 days
25	Install built-in furniture in the cashier area	3 days	Mon 6/19/00	Wed 6/21/00	Mon 6/19/00	Wed 6/21/00	Wed 6/21/00	Fri 6/23/00	0 days	2 days
26	Paint and trim in the cashier area	1 day	Thu 6/22/00	Thu 6/22/00	Thu 6/22/00	Sat 6/24/00	Thu 6/22/00	Sat 6/24/00	2 days	2 days
27	Prepare built-in furniture in the sale area	21 days	Mon 5/15/00	Sun 6/4/00	Mon 5/15/00	Tue 5/23/00	Sun 6/4/00	Mon 6/12/00	8 days	8 days
28	Install utility systems in the sale area	16 days	Sat 5/13/00	Sun 5/28/00	Sat 5/13/00	Sun 5/14/00	Sun 5/28/00	Mon 5/29/00	1 day	1 day
29	Install ground electricity system	5 days	Sat 5/13/00	Wed 5/17/00	Sat 5/13/00	Sat 5/13/00	Wed 5/17/00	Wed 5/17/00	0 days	0 days
30	Install partitions in the sale area	7 days	Thu 5/18/00	Wed 5/24/00	Thu 5/18/00	Thu 5/18/00	Wed 5/24/00	Wed 5/24/00	0 days	0 days
31	Place tooling and pave ground tiles in the sale area	5 days	Thu 5/25/00	Mon 5/29/00	Thu 5/25/00	Thu 5/25/00	Mon 5/29/00	Mon 5/29/00	0 days	0 days
32	Install ceiling in the sale area	19 days	Tue 5/30/00	Sat 6/17/00	Tue 5/30/00	Tue 5/30/00	Sat 6/17/00	Sat 6/17/00	0 days	0 days
33	Decorate partitions	14 days	Tue 5/30/00	Mon 6/12/00	Tue 5/30/00	Tue 5/30/00	Mon 6/12/00	Mon 6/12/00	0 days	0 days
34	Install built-in furniture in the sale area	5 days	Tue 6/13/00	Sat 6/17/00	Tue 6/13/00	Tue 6/13/00	Sat 6/17/00	Sat 6/17/00	0 days	0 days
35	Decorate general walls in the shop	14 days	Wed 5/31/00	Tue 6/13/00	Tue 5/30/00	Sun 6/4/00	Tue 6/13/00	Sat 6/17/00	4 days	4 days
36	Wash and paint ceiling in the sale area	3 days	Sun 6/18/00	Tue 6/20/00	Sun 6/18/00	Sun 6/18/00	Tue 6/20/00	Tue 6/20/00	0 days	0 days
37	Finish color in the shop	4 days	Wed 6/21/00	Sat 6/24/00	Wed 6/21/00	Wed 6/21/00	Sat 6/24/00	Sat 6/24/00	0 days	0 days
38	Send samples of loose furnitures	10 days	Fri 4/28/00	Mon 5/8/00	Fri 4/28/00	Thu 5/25/00	Mon 5/8/00	Sat 6/3/00	14 days	26 days
39	Assembly loose furnitures at the factory	21 days	Tue 5/23/00	Mon 6/12/00	Tue 5/23/00	Sun 6/4/00	Mon 6/12/00	Sat 6/24/00	12 days	12 days
40	Install loose furnitures	4 days	Sun 6/25/00	Wed 6/28/00	Sun 6/25/00	Sun 6/25/00	Wed 6/28/00	Wed 6/28/00	0 days	0 days
41	Prepare the panel of doors	7 days	Sun 6/18/00	Sat 6/24/00	Sun 6/18/00	Thu 6/22/00	Sat 6/24/00	Wed 6/28/00	4 days	4 days
42	Install doors and equipment	2 days	Thu 6/29/00	Fri 6/30/00	Thu 6/29/00	Thu 6/29/00	Fri 6/30/00	Fri 6/30/00	0 days	0 days
43	COMMISSIONING & TEST RUN	2 days	Sat 7/1/00	Sun 7/2/00	Sat 7/1/00	Sat 7/1/00	Sun 7/2/00	Sun 7/2/00	0 days	0 days
44	Clean the site	2 days	Mon 7/3/00	Tue 7/4/00	Mon 7/3/00	Mon 7/3/00	Tue 7/4/00	Tue 7/4/00	0 days	0 days

Table 5-3: The information about early start, latest start, early finish, late finish, free slack, and total slack for each activity

5.5.3 The Material Plan

After developing the project schedule, the material check sheets as shown in the chapter 4 had been created for the project by using the cost calculation forms of the company (see the material check sheets in appendix C). From the check sheets, besides the information about materials for each activity, it can be seen that the lead-time for common materials, such as plywood, foam, laminate sheets, teak wood, and etc. is 3 days; whereas, the lead-time for stone sheets is 7 days. And for stainless works, they have 28 days' lead-time since they are made-to-order work pieces. In addition, if the value of the common material is about or exceed bath 20,000, safety lead-time should be available for 2 days in order to allocate the budget for this material item. The project manager should order this material 5 days before the wanted time. The material should be available when the activity will begin.

In regard to the control level of materials, the Pareto principal of the "significant few and the insignificant many" or "20:80" is applied to analyze the signification of each material item. . It is often found that a large proportion of material costs of the project (80%) are due to a small number of materials items (20%). In addition, this method also shows the need for good data as the basis for decision-making on where to apply effort to reduce the material costs of the project, by reducing the costs and controlling the usage of the significant items first.

The Pareto analysis can be activated by sorting the value of each material item (see in appendix D). From the Pareto analysis, there are only 6 material items of total 79 items or only 7.59%, stainless legs, stainless works, mezzanine structure, RSM 011 green tiles $12''x12''$, green Russian granite sheets 0.3x0.6 m., and stone top, sum of which causes 65.14% of the total material costs. These materials will be classified as control level A. The usages and procurements should be controlled strictly to control the project cost efficiently. The reduction in the level A materials will affect the major material costs of the project. Regardless of the different maintenance costs among each material item, the level A materials should not be stocked for a long time since it will cause high inventory costs due to high sinking costs. They should be ordered and delivered only enough for the usage in each activity or for usage in very short period. And, the following 8 items, Para plywood 10 mm., stainless mirror edge, white-cream tiles of $8''x8''$ COTTO, frame wood $1''$ x$2''$ x2.5 m., Formica No. 4627-60, frame wood $1.5''$ x$3''$ x$6'$ and $1.5''$ x$3''$ x$5'$, and metal stud lined panel 2 sides, will cause about 18.16% of the total material costs. These items will be classified as control level group B. The strictness in controlling the usages and the procurement of the level B items is the second priority after the level A items. They should be also not stocked for a long time but they can be stocked for usage in a short period for example, 1 week and 2 weeks. Whereas, other 65 items will cause only 16.7% of the total material costs. These items will be grouped into the level C materials. From all mentioned, it can be concluded that only 14 material items of the total 79 items, or about 18% of the number of all material items, cause about 83% of the total material costs of the project.

However, in actual, many items were outsourced the procurement function to the subcontractors. The procurement functions of the 3 of 6 items in level A materials, stainless works, mezzanine structure, and tiles were outsourced to the subcontractors. In outsourcing the procurement function, the material costs will be included in the subcontract expense. An interesting question for these is if this outsourcing is a better choice than the integration of the procurement function. Is it cheaper if we acquire those materials by ourselves? Anyway, the company has no formal answer for this question. In

addition, there are many materials are not included in the list in the appendix 4 since they were not estimated in detailed during the biding stage of the project and, thus, their procurement were outsourced to the subcontractors. And some materials could not be assigned into the activity clearly since some activities have close relation with one another. For example, decorating the partitions and the general walls in the sale area, the work natures and materials applied in these two activities are not quite different. Their difference is only different areas, which are close to each other on the same major area. Moreover, in the cost estimation forms of the company, the materials used in these two tasks were combined together.

One interesting point for material planning is where the material should be stocked. From the table 1, the action plan, it could be seen that there are only 5 activities that must be activated at the factory of the company. They are preparing built-in furniture in the cashier area and the sale area, sending loose furniture samples, assembling loose furniture, and prepare the door panel. Only materials used in these activities have the transformation processes at the factory. From the material check sheets in appendix 3, the value of them is about bath 350,000 from the total material costs bath 2,100,000, or only 16.7 % of the total material costs. Most of the materials used in these five activities are in level C. These illustrate that 83.3% of the total value of the materials used in this project was used in the operation process at the site. In addition, most of the company's suppliers are closer to the project site than the factory of the company. There are many of them located between the factory and the project site. Thus, in order to reduce the delivery cost due to rather the long traveling distance between the factory and the project site, and the inventory cost, the suggestion for this situation is to stock only the materials used in those activities, whereas, the others should be, directly, delivered to the project site, or stocked at the project site and the suppliers. However, these suggestions were not applied because of five reasons as follows:

1. There is no space available to stock the materials at the site.

2. There is no one who will check and protect the materials at the site.

3. No suppliers are on working time at the delivery time, 10.00 pm.

As a result, all the materials that are not outsourced the procurement function to the subcontractors must be stocked at the factory and then delivered to the project site when they are needed. Regardless of the added delivery cost, and the loss due to the inventory area, there are many activities that make the company allocate its resource more to this project. They are loading materials in-out the trucks, checking the quantity when the materials are delivered in-out, and maintaining the materials. Especially, all of these activities are done by the skilled workforces of the company.

5.6 The Project Tracking

After the beginning of the project, the project progress was tracked on every Friday. The completeness of each activity had been estimated by the experience project manager. However, there is a significant problem in applying the project plan that must be mentioned before discussion about the tracking results. Since the researcher was a full-time student, the project control function was activated by the project managers of the company. The project managers, although, involves in developing the project plan, they tend to leave the project to go on its way. They just considered the plan at the beginning of the project and then left it away or in the project document file. There are three main reasons leading to this problem.

1. They were not use to applying the format of MP98. They said the format was rather difficult to be read or interpreted. This reason is more critical, when the schedule was presented to the company's subcontractors. They did not understand exactly what it means. They used to applying the traditional schedule written by hand.

2. The project managers use to planning the project in their head. As mentioned as the traditional method in the previous section, the bar chart is normally created at the beginning of the project and then it will be in the project document file, permanently.

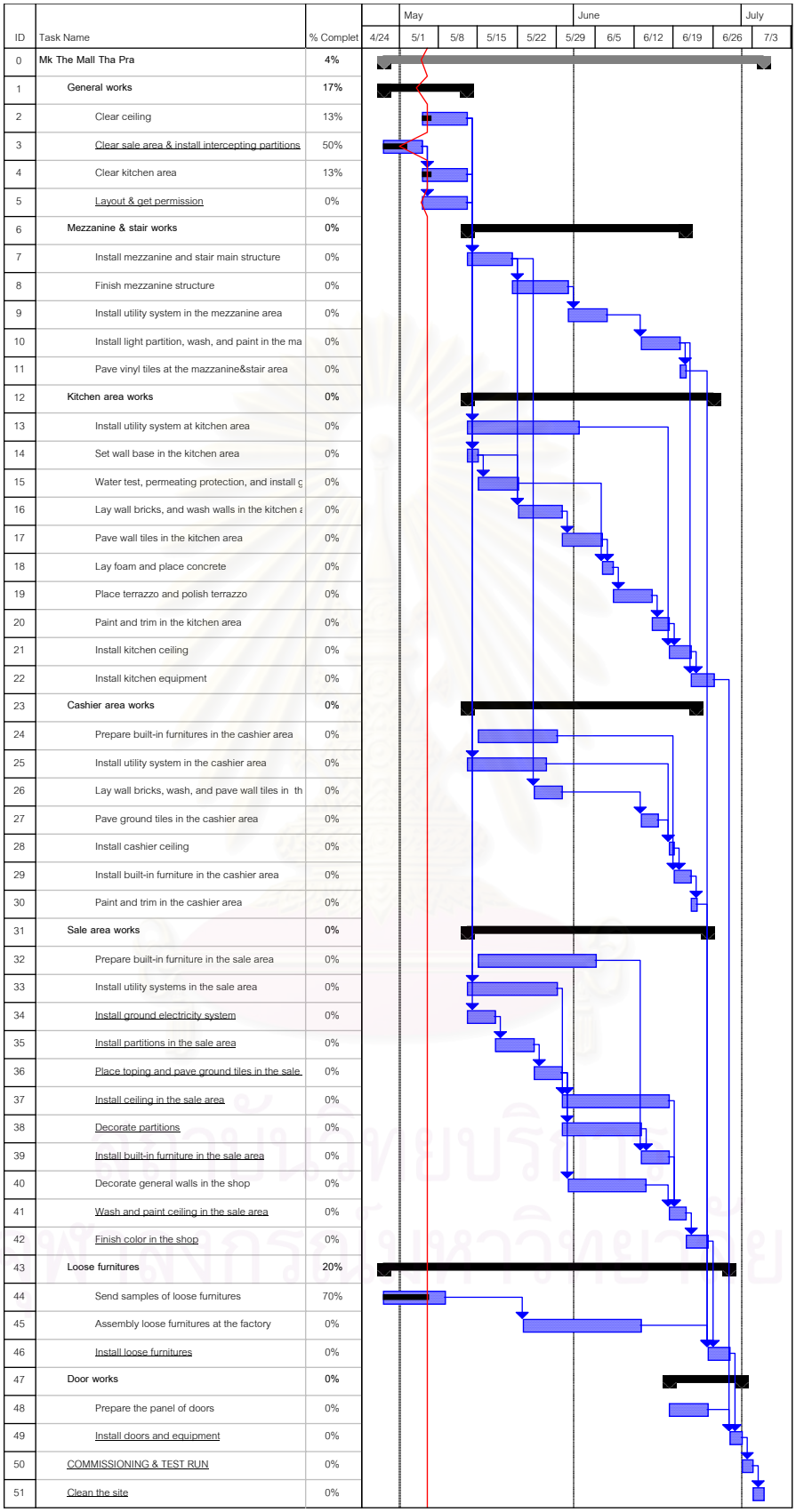
3. The project managers do not understand well about the network analysis technique. "Now, what is the critical activity?", "How much does the project delay?", and "how much is slack time available for this activity?", are always the questions through the project.

Moreover, no commitments are given by other project groups, especially, by the consultant due to the lack of communication. As a result, the project plan developed in the previous section tended to be used as a baseline plan of the project instead of being applied as the action plan of the project. In actual, there were many revisions had made on the plan during the project due to the significant delay. However, in order to not cause the confusion, the project plan mentioned before will be used as the only one baseline plan. Moreover, the usability of the material check sheets would also reduce due to the unreliable schedule.

5.6.1 The Project Progress as at May 5, 2000

The project progress as at May 5, 2000 can be seen in the photos of the project site as figure 5-5, and concluded as the tracking chart as figure 5-6. From the figure 5-5 & 5-6, it could be seen that the overall progress of the project was about 4%; whereas, the planed overall progress was 5%. The completeness of clearing ceiling, clearing sale area & installing intercepting partitions, and clearing kitchen area are 13%, 50%, and 13% respectively. And the site layout had not been made, yet. On the other hand, the samples of loose furniture had been assembled since 27 April 2000 and had the completeness of 70%. The delay was occurred, mainly, in clearing sale area. This delay was caused by the lack of the subcontractor's work forces. The 10 workers had cleared the site for only 3 days before tracking.

Figure 5-5: The photos of the project site as at May 5, 2000



ID	Task Name	% Complet
0	**Mk The Mall Tha Pra**	**4%**
1	**General works**	**17%**
2	Clear ceiling	13%
3	Clear sale area & install intercepting partitions	50%
4	Clear kitchen area	13%
5	Layout & get permission	0%
6	**Mezzanine & stair works**	**0%**
7	Install mezzanine and stair main structure	0%
8	Finish mezzanine structure	0%
9	Install utility system in the mezzanine area	0%
10	Install light partition, wash, and paint in the ma	0%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	**Kitchen area works**	**0%**
13	Install utility system at kitchen area	0%
14	Set wall base in the kitchen area	0%
15	Water test, permeating protection, and install g	0%
16	Lay wall bricks, and wash walls in the kitchen a	0%
17	Pave wall tiles in the kitchen area	0%
18	Lay foam and place concrete	0%
19	Place terrazzo and polish terrazzo	0%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	**Cashier area works**	**0%**
24	Prepare built-in furnitures in the cashier area	0%
25	Install utility system in the cashier area	0%
26	Lay wall bricks, wash, and pave wall tiles in th	0%
27	Pave ground tiles in the cashier area	0%
28	Install cashier ceiling	0%
29	Install built-in furniture in the cashier area	0%
30	Paint and trim in the cashier area	0%
31	**Sale area works**	**0%**
32	Prepare built-in furniture in the sale area	0%
33	Install utility systems in the sale area	0%
34	Install ground electricity system	0%
35	Install partitions in the sale area	0%
36	Place toping and pave ground tiles in the sale	0%
37	Install ceiling in the sale area	0%
38	Decorate partitions	0%
39	Install built-in furniture in the sale area	0%
40	Decorate general walls in the shop	0%
41	Wash and paint ceiling in the sale area	0%
42	Finish color in the shop	0%
43	**Loose furnitures**	**20%**
44	Send samples of loose furnitures	70%
45	Assembly loose furnitures at the factory	0%
46	Install loose furnitures	0%
47	**Door works**	**0%**
48	Prepare the panel of doors	0%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

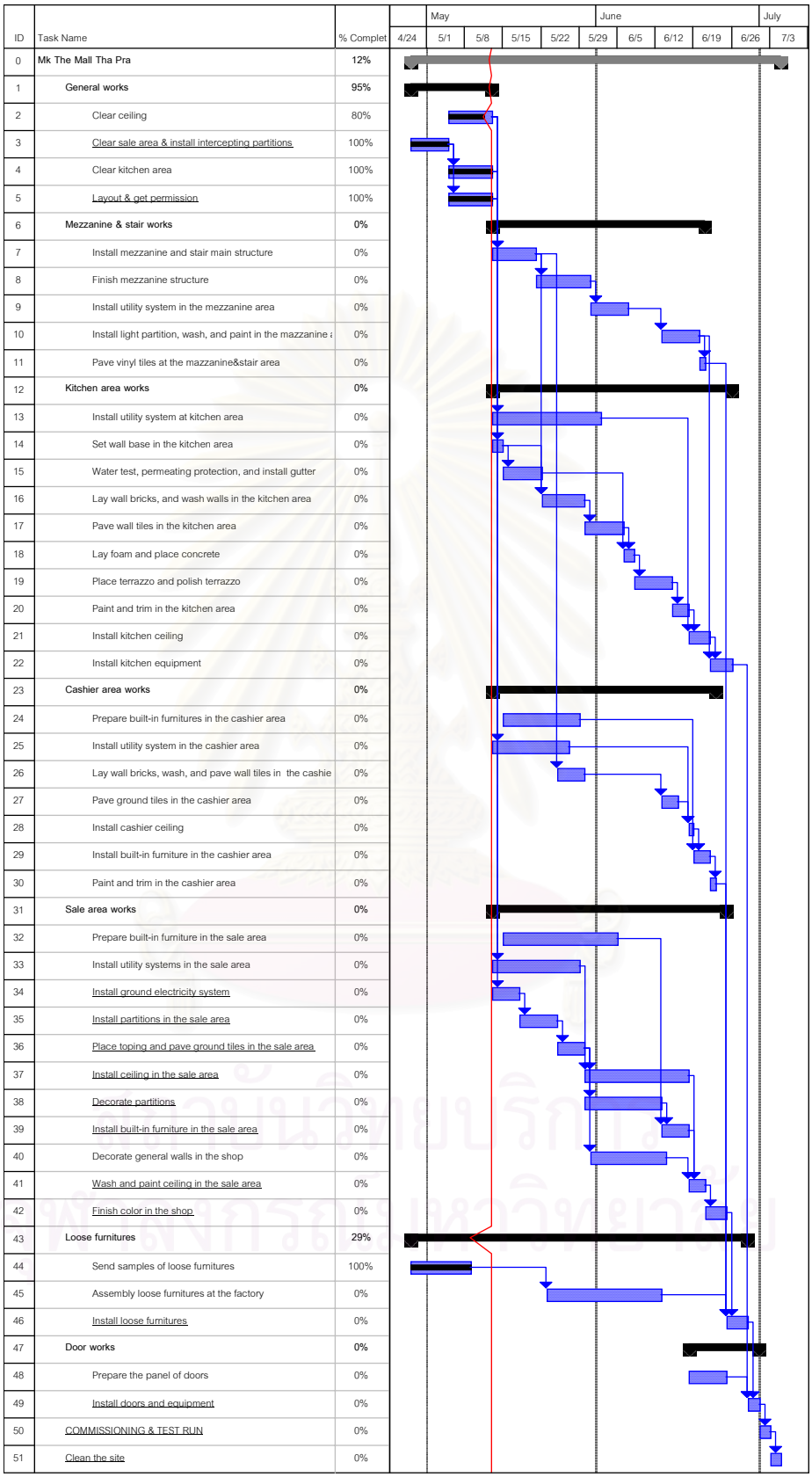
Figure 5-6: The tracking chart as at May 5, 2000

5.6.2 The Project Progress as at May 12, 2000

The project progress as at May 12, 2000 can be seen in the photos of the project site as figure 5-7, and concluded as the tracking chart as figure 5-8. From the figure 5-7 & 5-8, the overall progress of the project is about 12%. The layout had been made. Clearing sale area & installing intercepting partitions, and clearing kitchen area have been finished. And the samples of loose furniture had been sent to the consultant. However, the delay was occurred in clearing the ceiling, whose completeness is about 80%. The flexible conduits and the AHU were still on the ceiling.

From the observation, an interesting point in clearing activities is that, actually, they should take shorter time if there were enough workforces and the clear agreements in clearing the site. The real events were that some parts of the existing equipment belonged to the department store. Clearing those parts must be committed or activated by the department store. There were many stoppages in clearing when the workers doubted if those parts could be cleared without any problems. Moreover, in clearing the sale area, the company considered that the existing floor toping was still usable. Thus, they intent to not clear the floor toping but the consultant did not agree this point. They want the company to clear the existing toping and place the new one. This consumed more time and labor used than the company expected. In addition, since the site is on the second floor of the operating department store, hard equipment can not be used.

Figure 5-7: The photos of the project site as at May 12, 2000



ID	Task Name	% Complet
0	Mk The Mall Tha Pra	12%
1	General works	95%
2	Clear ceiling	80%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	Mezzanine & stair works	0%
7	Install mezzanine and stair main structure	0%
8	Finish mezzanine structure	0%
9	Install utility system in the mezzanine area	0%
10	Install light partition, wash, and paint in the mazzanine a	0%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	Kitchen area works	0%
13	Install utility system at kitchen area	0%
14	Set wall base in the kitchen area	0%
15	Water test, permeating protection, and install gutter	0%
16	Lay wall bricks, and wash walls in the kitchen area	0%
17	Pave wall tiles in the kitchen area	0%
18	Lay foam and place concrete	0%
19	Place terrazzo and polish terrazzo	0%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	Cashier area works	0%
24	Prepare built-in furnitures in the cashier area	0%
25	Install utility system in the cashier area	0%
26	Lay wall bricks, wash, and pave wall tiles in the cashie	0%
27	Pave ground tiles in the cashier area	0%
28	Install cashier ceiling	0%
29	Install built-in furniture in the cashier area	0%
30	Paint and trim in the cashier area	0%
31	Sale area works	0%
32	Prepare built-in furniture in the sale area	0%
33	Install utility systems in the sale area	0%
34	Install ground electricity system	0%
35	Install partitions in the sale area	0%
36	Place toping and pave ground tiles in the sale area	0%
37	Install ceiling in the sale area	0%
38	Decorate partitions	0%
39	Install built-in furniture in the sale area	0%
40	Decorate general walls in the shop	0%
41	Wash and paint ceiling in the sale area	0%
42	Finish color in the shop	0%
43	Loose furnitures	29%
44	Send samples of loose furnitures	100%
45	Assembly loose furnitures at the factory	0%
46	Install loose furnitures	0%
47	Door works	0%
48	Prepare the panel of doors	0%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-8: The tracking chart as at May 12, 2000

5.6.3 The Project Progress as at May 19, 2000

The project progress as at May 19, 2000 can be seen in the photos of the project site as figure 5-9, and concluded as the tracking chart as figure 5-10. From the figure 5-9 & 5-10, the overall progress of the project was about 13%; whereas, the planed progress was 28%.

General Works

Clearing the site activities, although, were said to be finished for the company's responsibilities. The conduits and AHU on the ceiling of the cashier area were still remained since they belonged to the department store. To remove them, the consultant must get the permission from the department store. Thus, the completeness of the clearing ceiling activity is about 90% at this tracking day.

Mezzanine & Stair works

About installing mezzanine and stair main structure, the iron structure had been delivered since May 15, 2000. But this iron structure still needed the cutting and welding operation until the tracking days. Moreover, there were only 3 ironworkers from the expected 7 ironworkers. Thus, the progress of this activity is only 15%.

Because of the difficulty in material delivery caused by the site location, and the pollutions caused by cutting and welding, the interesting point was if these operations could be activated outside the project site. Can the iron structure be cut and welded at the other place and then sent to the project site? If this can be activated, delivery costs will be reduced caused by the reduction in delivering iron scraps in and out the project site, and the pollutions leading to the fatigue of the workforces will be relieved. However, the answer for this question is "no" due to no available place.

Kitchen and Cashier Area Works

The progress in these two work areas was only finishing "setting wall base in the kitchen area" activity. No utility system had been being installed in these two areas, yet. However, there was an argument from the utility installation company that we could not do our jobs since the iron structure was not finished. While the experience project manager of the company said that some utility parts could be installed loosely. There were no needs to wait finishing the mezzanine main structure. The conclusion for this argument is not clear but this argument illustrated that there was no clear agreement among the groups involving the project. Anyway, from the network analysis whose analysis information shown in the table 3, installing utility system in kitchen and cashier areas has free slack time for 16 days and 20 days, respectively. And their late start dates are 1/6/00 and 4/6/00. Exceeding these dates, the project tended to be delay.

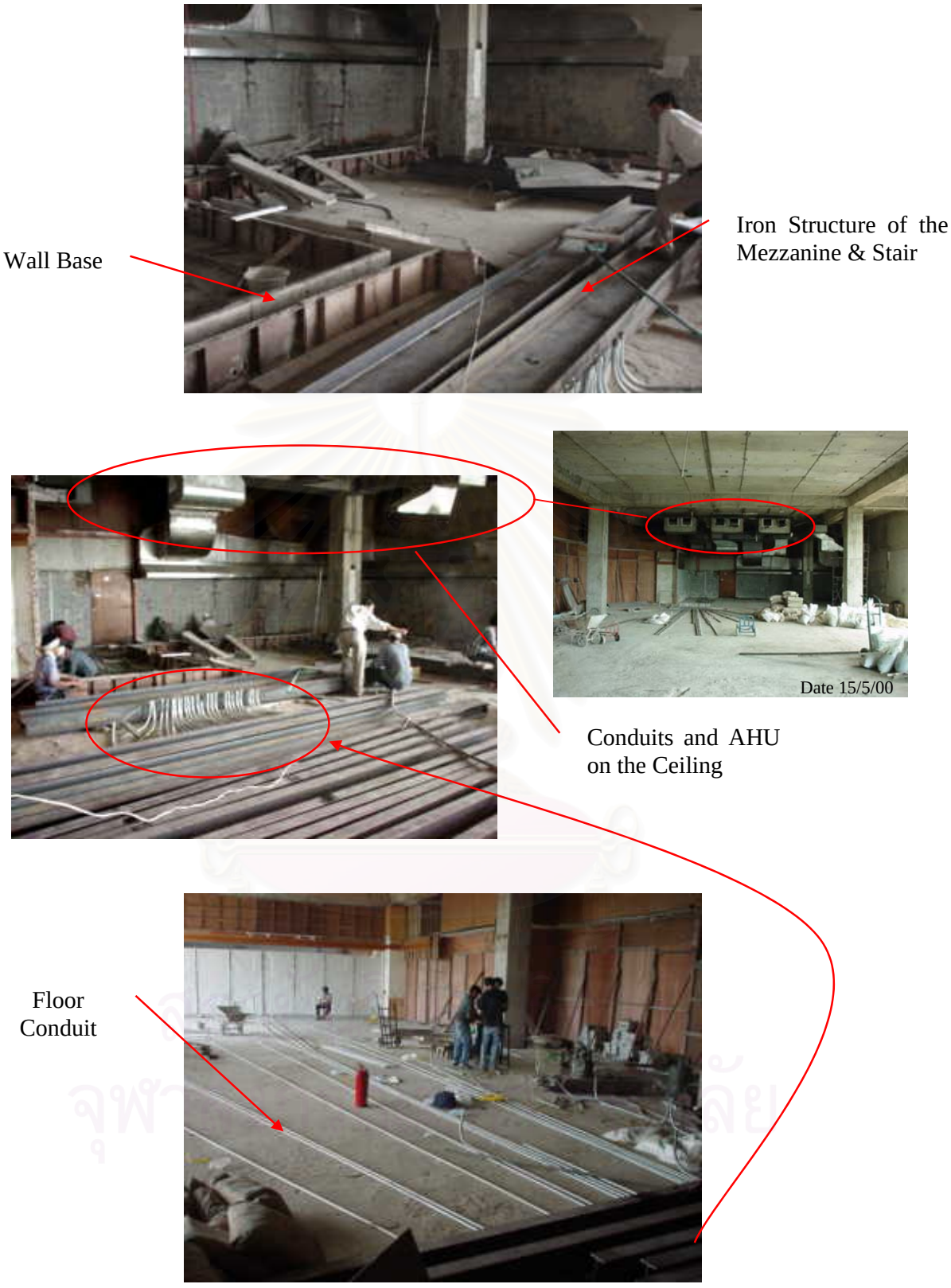
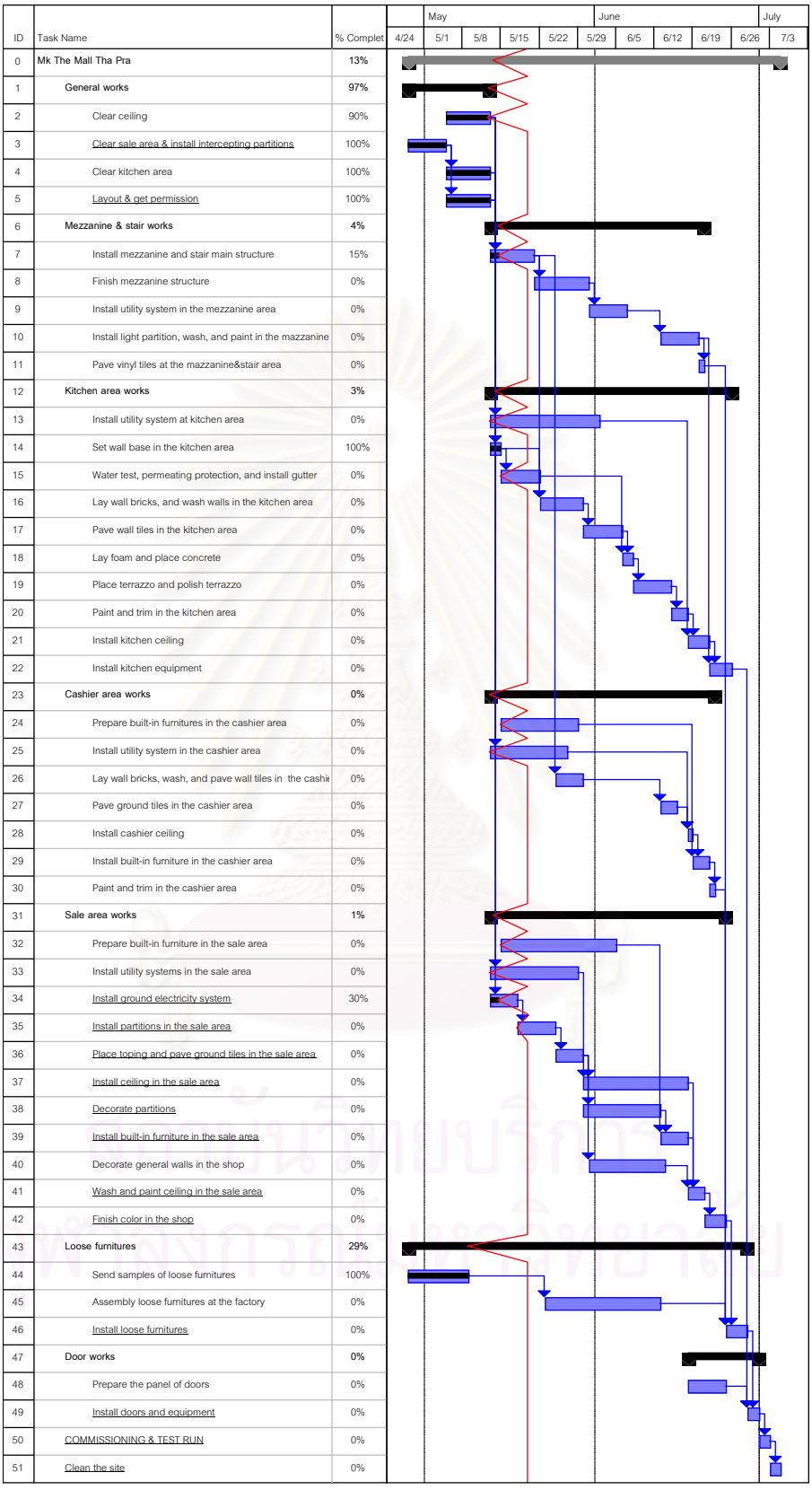


Figure 5-9: The photos of the project site as at May 19, 2000



ID	Task Name	% Complet
0	**Mk The Mall Tha Pra**	**13%**
1	**General works**	**97%**
2	Clear ceiling	90%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	**Mezzanine & stair works**	**4%**
7	Install mezzanine and stair main structure	15%
8	Finish mezzanine structure	0%
9	Install utility system in the mezzanine area	0%
10	Install light partition, wash, and paint in the mazzanine	0%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	**Kitchen area works**	**3%**
13	Install utility system at kitchen area	0%
14	Set wall base in the kitchen area	100%
15	Water test, permeating protection, and install gutter	0%
16	Lay wall bricks, and wash walls in the kitchen area	0%
17	Pave wall tiles in the kitchen area	0%
18	Lay foam and place concrete	0%
19	Place terrazzo and polish terrazzo	0%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	**Cashier area works**	**0%**
24	Prepare built-in furnitures in the cashier area	0%
25	Install utility system in the cashier area	0%
26	Lay wall bricks, wash, and pave wall tiles in the cashi	0%
27	Pave ground tiles in the cashier area	0%
28	Install cashier ceiling	0%
29	Install built-in furniture in the cashier area	0%
30	Paint and trim in the cashier area	0%
31	**Sale area works**	**1%**
32	Prepare built-in furniture in the sale area	0%
33	Install utility systems in the sale area	0%
34	Install ground electricity system	30%
35	Install partitions in the sale area	0%
36	Place toping and pave ground tiles in the sale area	0%
37	Install ceiling in the sale area	0%
38	Decorate partitions	0%
39	Install built-in furniture in the sale area	0%
40	Decorate general walls in the shop	0%
41	Wash and paint ceiling in the sale area	0%
42	Finish color in the shop	0%
43	**Loose furnitures**	**29%**
44	Send samples of loose furnitures	100%
45	Assembly loose furnitures at the factory	0%
46	Install loose furnitures	0%
47	**Door works**	**0%**
48	Prepare the panel of doors	0%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-10: The tracking chart as at May 19, 2000

Sale Area Works

An activity in the critical path, “install ground electricity system”, although, had been started since May 14, its completeness was only 30%; whereas, the planed progress should be finished 100%, and installing partition in the sale area should be begun. The delay of this activity is due to the conflict in the material details between the floor conduit and the available height between the floors of the cashier and sale areas as shown in figure 5-11.

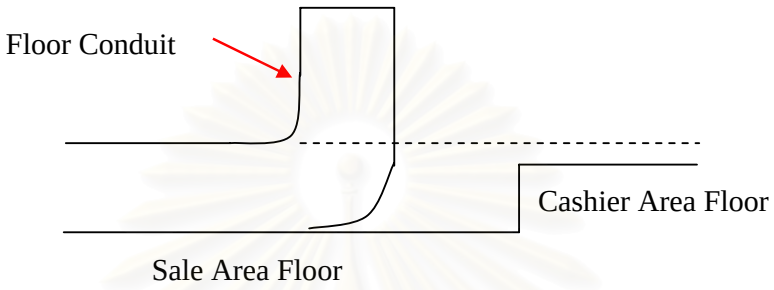


Figure 5-11: The conflict in the material details

In the plan given by the consultant, the floor toping intended to be placed after installing the ground electricity system and partition in the sale area by having the same level to the cashier area floor. However, after installing the ground electricity system had been activated for 2 days, it was found that the diameter of the floor conduit exceeds the available height between the floors of the cashier and sales areas. This will cause the trouble in paving floor tiles. There are two solutions for this problem as follows:

1. In installing the floor conduits, the floor in the sale area must be excavated to balance the different height.

2. After installing the floor conduits, the toping must be placed over both sale and cashier areas to balance the different level.

After finding the problem for 5 days, the consultant chose the second choice to place the toping over two areas after installing the floor conduits. This decision leaded to added costs to our subcontractor. In addition, during that 5 days including to the tracking days, there was no more progress of installing ground electricity system. And this activity was finished after the decision-making day for 3 days. Thus, the actual duration for this activity was 10 days by having 5 working days; whereas, the planed duration was only 5 days. In other words, it could be said that the project delayed for 5 days. In addition, there was no progress in the installation of the utility system on the ceiling of the sale area, the built-in furniture preparation, and the loose furniture assembly.

5.6.4 The Project Progress as at May 26, 2000

The project progress as at May 26, 2000 can be seen in the photos of the project site as figure 5-12, and concluded as the tracking chart as figure 5-13. From the figure 5-12 & 5-13, the overall progress of the project was only 20%; whereas, the planed progress was 47%.

General Works and Mezzanine & Stair Works

At this tracking day, conduits and AHU in the ceiling of the mezzanine still remained. And Iron main structure of the mezzanine was installed. The activities in the kitchen and cashier areas could be done or started. Thus, the completeness of installing mezzanine and stair main structure was about 100%.

Kitchen Area and Cashier Area Works

In the kitchen area, the first water test in the kitchen floor had been done causing the completeness of 30% of “water test, permeating protection, and install gutter” activity. And the progress of “lay wall bricks, and wash walls in the kitchen area” was about 50%. Wall bricks were laid and washed to the half of the needed height. However, there was no any progress of the activities in the cashier area.

Sale Area Works

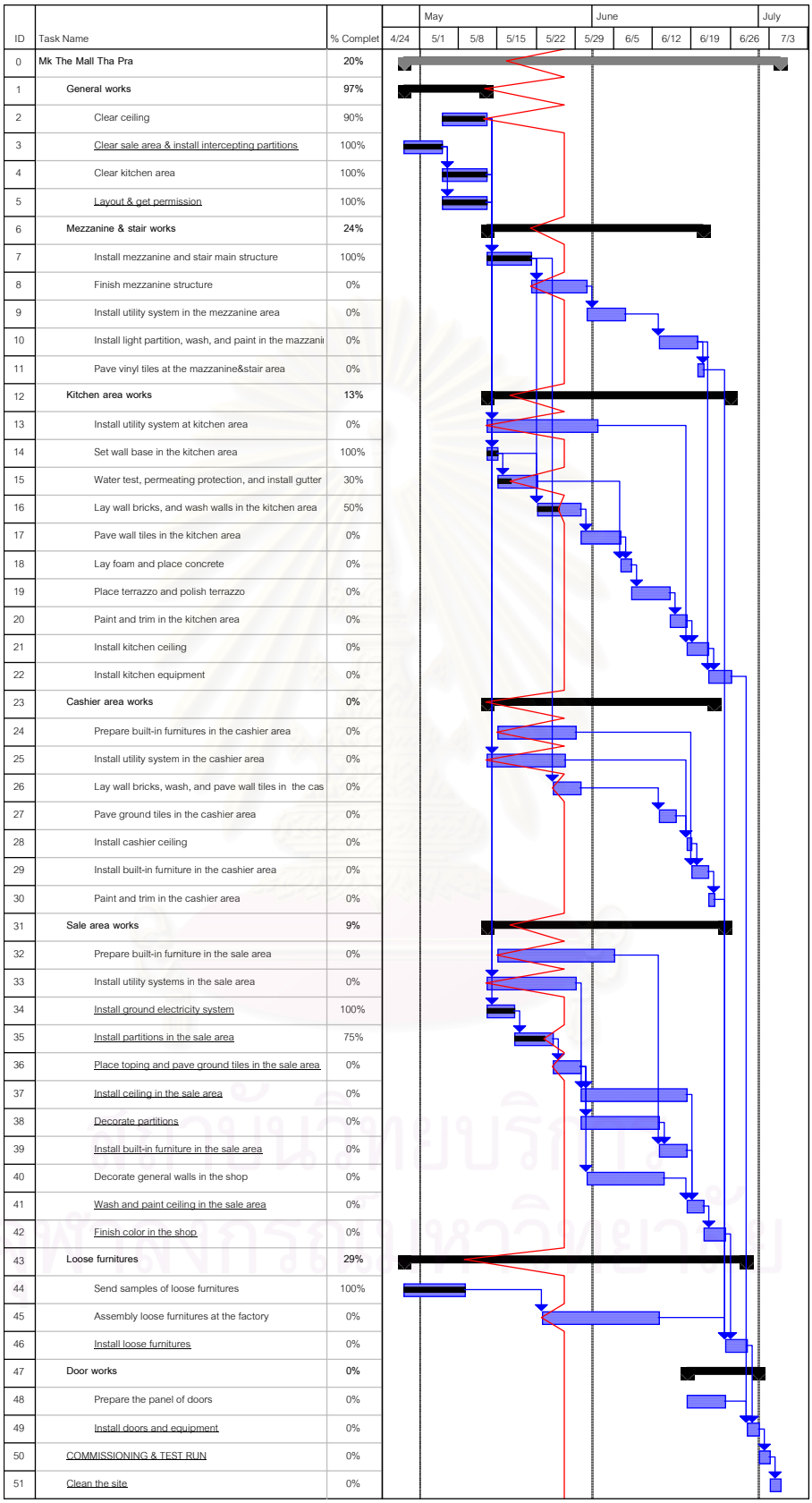
The installation of the ground electricity system had been finished; whereas, the progress of the partition installation was about 75%. According to the plan, this activity should be finished and placing toping should have been activated. Moreover, there was still no progress in installing the utility system on the ceiling of the sale area. The interesting point is why more brick masons were not allocated to install the partition in sale area instead of allocated some of them to lay wall brick in the kitchen area at the beginning of the week, since, from the information caused by the network analysis in table 5-3, “lay wall bricks, and wash walls in the kitchen area” activity had total slack time for three days, while “install partitions in the sale area” activity is a critical task: no any slack time available for this activity.

Partition

Mezzanine
Structure

Kitchen Floor

Figure 5-12: The photos of the project site as at May 26, 2000



ID	Task Name	% Complet
0	Mk The Mall Tha Pra	20%
1	General works	97%
2	Clear ceiling	90%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	Mezzanine & stair works	24%
7	Install mezzanine and stair main structure	100%
8	Finish mezzanine structure	0%
9	Install utility system in the mezzanine area	0%
10	Install light partition, wash, and paint in the mazzani	0%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	Kitchen area works	13%
13	Install utility system at kitchen area	0%
14	Set wall base in the kitchen area	100%
15	Water test, permeating protection, and install gutter	30%
16	Lay wall bricks, and wash walls in the kitchen area	50%
17	Pave wall tiles in the kitchen area	0%
18	Lay foam and place concrete	0%
19	Place terrazzo and polish terrazzo	0%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	Cashier area works	0%
24	Prepare built-in furnitures in the cashier area	0%
25	Install utility system in the cashier area	0%
26	Lay wall bricks, wash, and pave wall tiles in the cas	0%
27	Pave ground tiles in the cashier area	0%
28	Install cashier ceiling	0%
29	Install built-in furniture in the cashier area	0%
30	Paint and trim in the cashier area	0%
31	Sale area works	9%
32	Prepare built-in furniture in the sale area	0%
33	Install utility systems in the sale area	0%
34	Install ground electricity system	100%
35	Install partitions in the sale area	75%
36	Place toping and pave ground tiles in the sale area	0%
37	Install ceiling in the sale area	0%
38	Decorate partitions	0%
39	Install built-in furniture in the sale area	0%
40	Decorate general walls in the shop	0%
41	Wash and paint ceiling in the sale area	0%
42	Finish color in the shop	0%
43	Loose furnitures	29%
44	Send samples of loose furnitures	100%
45	Assembly loose furnitures at the factory	0%
46	Install loose furnitures	0%
47	Door works	0%
48	Prepare the panel of doors	0%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-13: The tracking chart as at May 26, 2000

5.6.5 The Project Progress as at June 2, 2000

The project progress as at June 2, 2000 can be seen in the photos of the project site as figure 5-14, and concluded as the tracking chart as figure 5-15. From the figure 5-14 & 5-15, the overall progress of the project was only 27%; whereas, the planed progress was 64%.

General Works and Mezzanine & Stair Works

About the general works, conduits and AHU on the ceiling of the mezzanine still remained. And according to the mezzanine & stair, the progress of finishing the detail works of main structure was only 20%. This was mainly due to the stoppage of iron works in the mezzanine structure since May 29. Because the department store‘s structure engineers considered that the weight of the structure will be overloaded the department store’s structure. After the stoppage, the ironworkers changed to install the structure at the main entrance as shown in figure 5-14. At this point, it could be seen that the project network had been created in the previous section did not include all project activities. Installing mirror structure at the main entrance could be activated at the same time with installing the utility system on the ceiling of the sale area. It consumes about 4 working days of 3 workers.

Kitchen Area and Cashier Area Works

In the kitchen area, the permeating protection had been done causing the completeness of 60% of “water test, permeating protection, and install gutter” activity. And the progress of “lay wall bricks, and wash walls in the kitchen area” was about 75% as seen in figure 5-11. At the end of tracking days, the internal side of kitchen wall were laid and washed to the needed height. Whereas, according to the schedule, all kitchen walls should have been washed and paving wall tile should be continued. Anyway, there was still no any progress of the activities in the cashier area. The delay in these two areas was, mostly, caused by the lack of available workforces. In some days, there were only 5 builders from the estimated number of 11–14 workers. The hidden reason for this was because the subcontractor had no enough workforces to allocate the estimated number of workers to this project. The subcontractor was handling other projects.

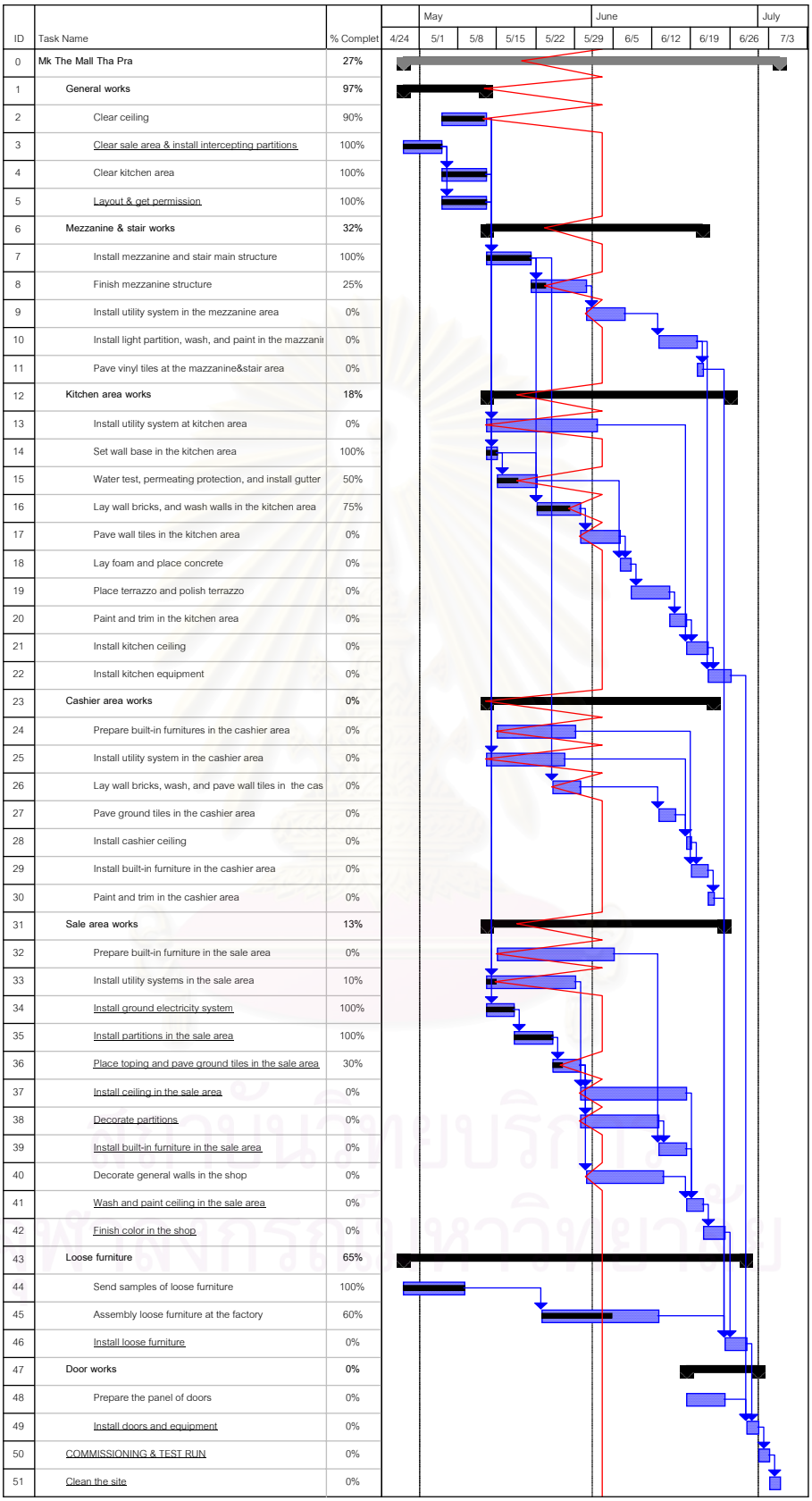
Sale Area Works and Loose Furniture

In the sale area, installing the partitions had been finished and the toping would be finished at the end of the tracking day. So, the completeness of the “place toping, and pave ground tiles in the sale area” was about 30%. About the utility system installation in the sale area, the operation had begun at this tracking day. And its completeness was about 10%. There were only connecting steel strings installed on the ceiling. According to the loose furniture, the progress of the loose furniture is about 60% at the company’s factory.

Iron structure at the main entrance

Kitchen Wall

Figure 5-14: The photos of the project site as at June 2, 2000



ID	Task Name	% Complet
0	**Mk The Mall Tha Pra**	**27%**
1	**General works**	**97%**
2	Clear ceiling	90%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	**Mezzanine & stair works**	**32%**
7	Install mezzanine and stair main structure	100%
8	Finish mezzanine structure	25%
9	Install utility system in the mezzanine area	0%
10	Install light partition, wash, and paint in the mazzanii	0%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	**Kitchen area works**	**18%**
13	Install utility system at kitchen area	0%
14	Set wall base in the kitchen area	100%
15	Water test, permeating protection, and install gutter	50%
16	Lay wall bricks, and wash walls in the kitchen area	75%
17	Pave wall tiles in the kitchen area	0%
18	Lay foam and place concrete	0%
19	Place terrazzo and polish terrazzo	0%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	**Cashier area works**	**0%**
24	Prepare built-in furnitures in the cashier area	0%
25	Install utility system in the cashier area	0%
26	Lay wall bricks, wash, and pave wall tiles in the cas	0%
27	Pave ground tiles in the cashier area	0%
28	Install cashier ceiling	0%
29	Install built-in furniture in the cashier area	0%
30	Paint and trim in the cashier area	0%
31	**Sale area works**	**13%**
32	Prepare built-in furniture in the sale area	0%
33	Install utility systems in the sale area	10%
34	Install ground electricity system	100%
35	Install partitions in the sale area	100%
36	Place toping and pave ground tiles in the sale area	30%
37	Install ceiling in the sale area	0%
38	Decorate partitions	0%
39	Install built-in furniture in the sale area	0%
40	Decorate general walls in the shop	0%
41	Wash and paint ceiling in the sale area	0%
42	Finish color in the shop	0%
43	**Loose furniture**	**65%**
44	Send samples of loose furniture	100%
45	Assembly loose furniture at the factory	60%
46	Install loose furniture	0%
47	**Door works**	**0%**
48	Prepare the panel of doors	0%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-15: The tracking chart as at June 2, 2000

5.6.6 The Project Progress as at June 9, 2000

The project progress as at June 9, 2000 can be seen in the photos of the project site as figure 5-16, and concluded as the tracking chart as figure 5-17. From the figure 5-16 & 5-17, the overall progress of the project was only 34%; whereas, the planed progress was 76%.

General Works and Mezzanine & Stair Works

About the general works, conduits and AHU on the ceiling of the mezzanine still remained as can be seen in the figure 5-16. The progress of finishing the detail works of main structure of the mezzanine & stair was 75% after the 7 days' stoppage. Whereas, the iron structure at the main entrance had been installed.

Kitchen Area and Cashier Area Works

In the kitchen area, the gutter installation, laying bricks, and washing walls in the kitchen area had been finished. Paving wall tiles in the kitchen area was done only enough to lay the foam sheets in the kitchen area. Their completeness was about 30% and 50%, respectively. According to the cashier area, the completeness of "lay wall bricks, wash, and pave wall tiles in the cashier" activity was about only 20%. Laying bricks and washing walls in the kitchen area were, although, considered to be finished, there were reworks on the walls of the kitchen. Some of them must be cleared and lay bricks again. This is, mainly, due to the toping that will be mentioned in the sale area works. In addition, there was no progress in the utility installation in these two areas.

Sales Area Works and Loose Furniture

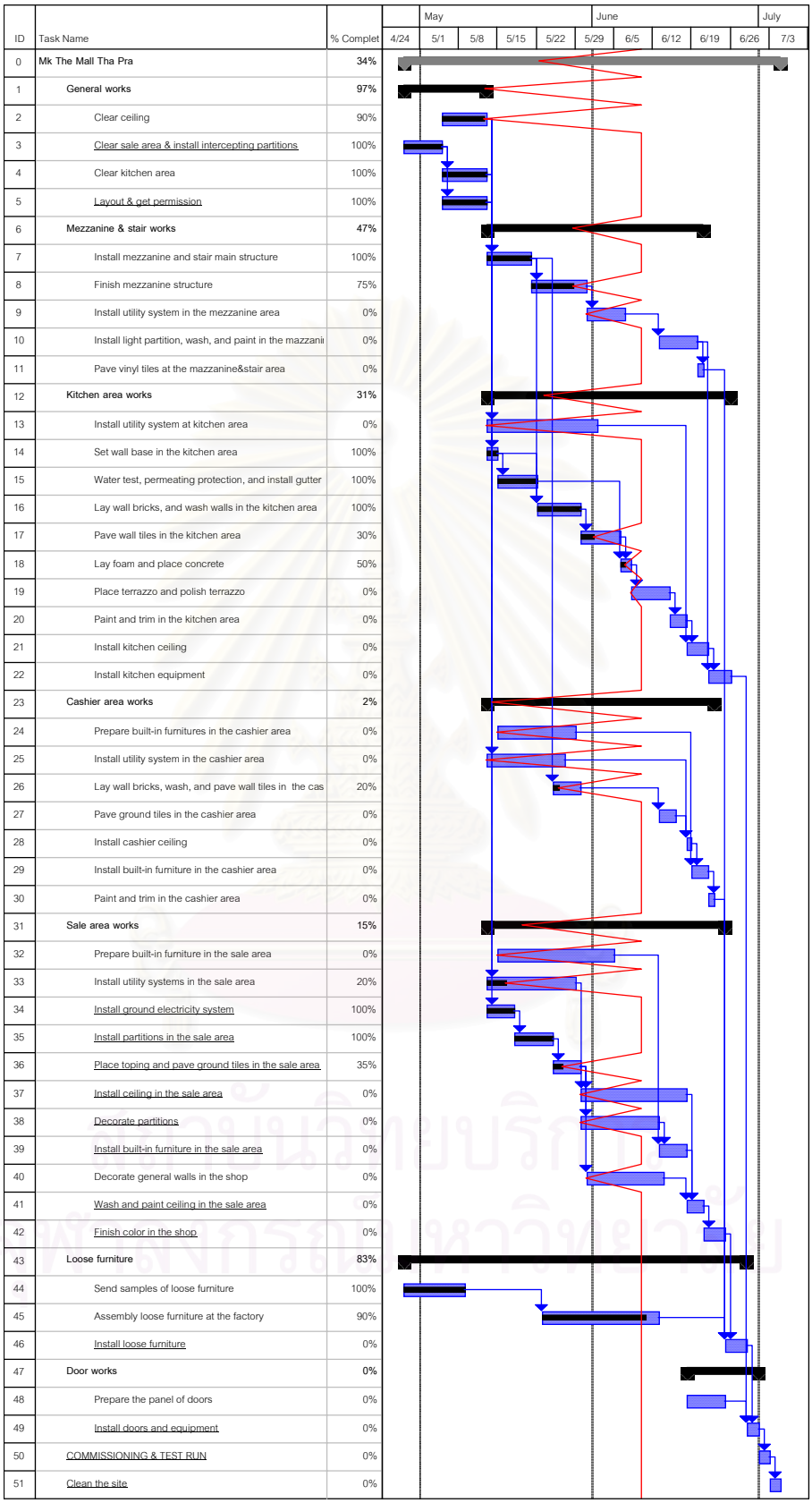
Although, the toping had been finished since June 4, the progress of the "place toping and pave ground tiles in the sale areas" activity was only 35%. Paving floor tile had been begun in the tracking days. In the other word, its progress was increased only 5% from the last tracking days or last weeks. There are two causes leading to this delay.

1. The material management in the project site is poor. During the week, the materials, especially, tiles boxes, were, almost, located at everywhere in the site. All tiles used in the project had been delivered in boxes since last week. Their locations in the site led to the difficulty in operating activities in the sale area. Before paving the floor tiles, those materials must be rearranged in order to have enough space in the needed area.

2. After placing the toping, there were many reworks of the walls occurred. Many builders must be allocated to these reworks leading to the lack of workforces to activated other activities. It was estimated that the reworks of the walls were about 50% of the overall wall area. Almost 50% of them must be cleared and then laid brick again. These reworks of the walls were, generally, because the layout lines were deleted by placing the toping. The layout must be made again.

Figure 5-16: The photos of the project site as at June 9, 2000

Figure 5-16: The photos of the project site as at June 9, 2000 (Continued)



ID	Task Name	% Complet
0	**Mk The Mall Tha Pra**	**34%**
1	**General works**	**97%**
2	Clear ceiling	90%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	**Mezzanine & stair works**	**47%**
7	Install mezzanine and stair main structure	100%
8	Finish mezzanine structure	75%
9	Install utility system in the mezzanine area	0%
10	Install light partition, wash, and paint in the mazzani	0%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	**Kitchen area works**	**31%**
13	Install utility system at kitchen area	0%
14	Set wall base in the kitchen area	100%
15	Water test, permeating protection, and install gutter	100%
16	Lay wall bricks, and wash walls in the kitchen area	100%
17	Pave wall tiles in the kitchen area	30%
18	Lay foam and place concrete	50%
19	Place terrazzo and polish terrazzo	0%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	**Cashier area works**	**2%**
24	Prepare built-in furnitures in the cashier area	0%
25	Install utility system in the cashier area	0%
26	Lay wall bricks, wash, and pave wall tiles in the cas	20%
27	Pave ground tiles in the cashier area	0%
28	Install cashier ceiling	0%
29	Install built-in furniture in the cashier area	0%
30	Paint and trim in the cashier area	0%
31	**Sale area works**	**15%**
32	Prepare built-in furniture in the sale area	0%
33	Install utility systems in the sale area	20%
34	Install ground electricity system	100%
35	Install partitions in the sale area	100%
36	Place toping and pave ground tiles in the sale area	35%
37	Install ceiling in the sale area	0%
38	Decorate partitions	0%
39	Install built-in furniture in the sale area	0%
40	Decorate general walls in the shop	0%
41	Wash and paint ceiling in the sale area	0%
42	Finish color in the shop	0%
43	**Loose furniture**	**83%**
44	Send samples of loose furniture	100%
45	Assembly loose furniture at the factory	90%
46	Install loose furniture	0%
47	**Door works**	**0%**
48	Prepare the panel of doors	0%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-17: The tracking chart as at June 9, 2000

Since when the new layout was made, there must be some variances from the original one because the layout was done manually. And, in the design, each wall's spans will have the relations with one another. As a result, the variances occurred from the new layout affected these relation, which led to the errors from the design. This led to the reworks of the walls, which almost occurred 50% of the overall wall area of the project. There were two solutions to avoid these reworks by not making the new layout as follows:

1. Every walls of the project, including in the kitchen and cashier area, must be washed before placing the toping. This solution is to make no needs to make the new layout since its usage is out.

2. In clearing the project site, the toping should be placed at the same level in all areas. And there must be the excavation in the ground conduit installation. This solution is to not delete the existing layout by placing toping again after installing the ground conduit.

However, these two solutions were rather benefit-loss choices between the company's subcontractor, and the utility installation company. Since, if the consultant chooses the first solution to place the toping again, the load will be on the company's subcontractor; whereas, if the second choice is chosen to let the utility installation company excavate the existing toping, the load will be on the utility installation company. Anyway, for this project, the second solution tent to be more considerable choice because it will consume less time than the first as no activities in the sale area were preceded by the mezzanine structure installation. Whereas, regarding to the first choice, laying brick and washing wall in the kitchen and sale areas must be preceded the mezzanine structure installation, leading to more consumed time.

According to the utility system in the sale area, the progress was only 20% as seen in the figure 5-16. This was because this tracking day was only the second working days of the utility workers from the last tracking days, or last Friday. At that time, the project manager commented whether they worked every Friday that is the tracking day of the consultant. Again, this illustrated the lack of the commitment given to the schedule from every project groups. In addition, there was still no progress in the built-in furniture preparation at the factory. The project manager thought that the built-in furniture preparation was not needed at this time due to the project delay at the project site. However, the completeness of assembling loose furniture was about 90%.

5.6.7 The Project Progress as at June 16, 2000

The project progress as at June 16, 2000 can be seen in the photos of the project site as figure 5-19, and concluded as the tracking chart as figure 5-20. From the figure 5-19 & 5-20, the overall progress of the project was only 42%; whereas, the planed progress was 87%.

General Works and Mezzanine & Stair Works

About the general works, conduits and AHU on the ceiling of the mezzanine still remained as can be seen in the figure 5-19. The progress of finishing the detail works of main structure of the mezzanine & stair was finished in this tracking day. The stair structure had been installed.

Kitchen Area and Cashier Area Works

In the kitchen area, the concrete and terrazzo had been placed. Whereas, the completeness of paving wall tiles in the kitchen were 80% since, after placing the concrete and terrazzo, no operation could be done in the internal side of the kitchen leading to the stoppage of the operation. Paving wall tiles in the internal side of the kitchen could be continued after the setting time of concrete and terrazzo. According to placing and polishing terrazzo floor, the placing and polishing operation were, actually, 1-2 days' operations. But there was the 5-day setting time between placing and polishing the terrazzo. The polishing operation had 5-day lead-time after placing terrazzo.

According to the cashier area, the completeness of the utility system installation was about 20%. The wall conduits had been installed; whereas, the progress of the wall in the cashier area was about 50%.

Sales Area Works and Loose Furniture

The completeness of the utility installation on the ceiling of the sale area was about 60%; whereas, the completeness of the floor in the sale area was about 80%. Although paving ground tiles was not finished, the partition decoration had been begun and its progress was about 10%.

In decorating the partitions in the sale area of this project, there are two main types of the partitions grouped the materials used as shown in figure 5-18. The first group of partitions is decorated one side by granite sheet with 2 cm thickness, and its other side is decorated by plywood or wall tiles with 1 cm thickness. On the other hand, the other group is decorated both sides by plywood or walls tile with 1 cm thickness. When these thickness of decorated materials includes with the thickness of common-size brick, and two normal wash and adhesive areas, which are 6.5 cm and 1 cm per side, respectively. The first group partition will have total thickness of 11.5 cm; whereas, the other will have total thickness of 10.5 cm.

The point caused the needs to illustrate these partition details is that, in the given design, the wanted dimension of the thickness of all partitions in this project is only 10 cm. The solution for this problem is to wash the partition, more slightly by half of its common thickness for the second group of partitions; whereas, washing more slightly is

not enough for the first partition group. Besides washing more slightly by half of its common thickness, chiseling the partition to eliminate 1 cm thickness of the partition needs to be activated. This leads to the unnecessary chisel work of the first group partitions that are estimated to be 40% of the overall partitions in the sale area since if the design assigns suitable dimension, this work will be needless and the work duration can be reduced. Since, decorating partitions in the sale area is a critical task, the reduction in its duration will cause the reduction in the overall project duration. However, the hidden reason for 10 cm dimension is to reduce the material costs of the stainless works, which are used to be decorated the top of the partition. Anyway, the trade-off analysis should be made between the reductions in the material costs, and in the project duration.

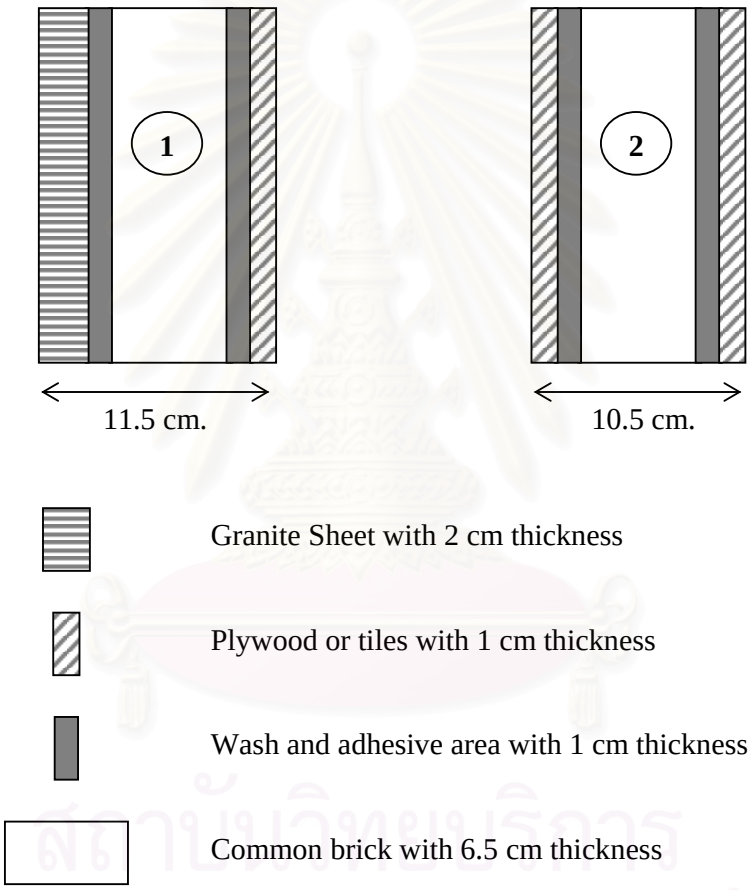


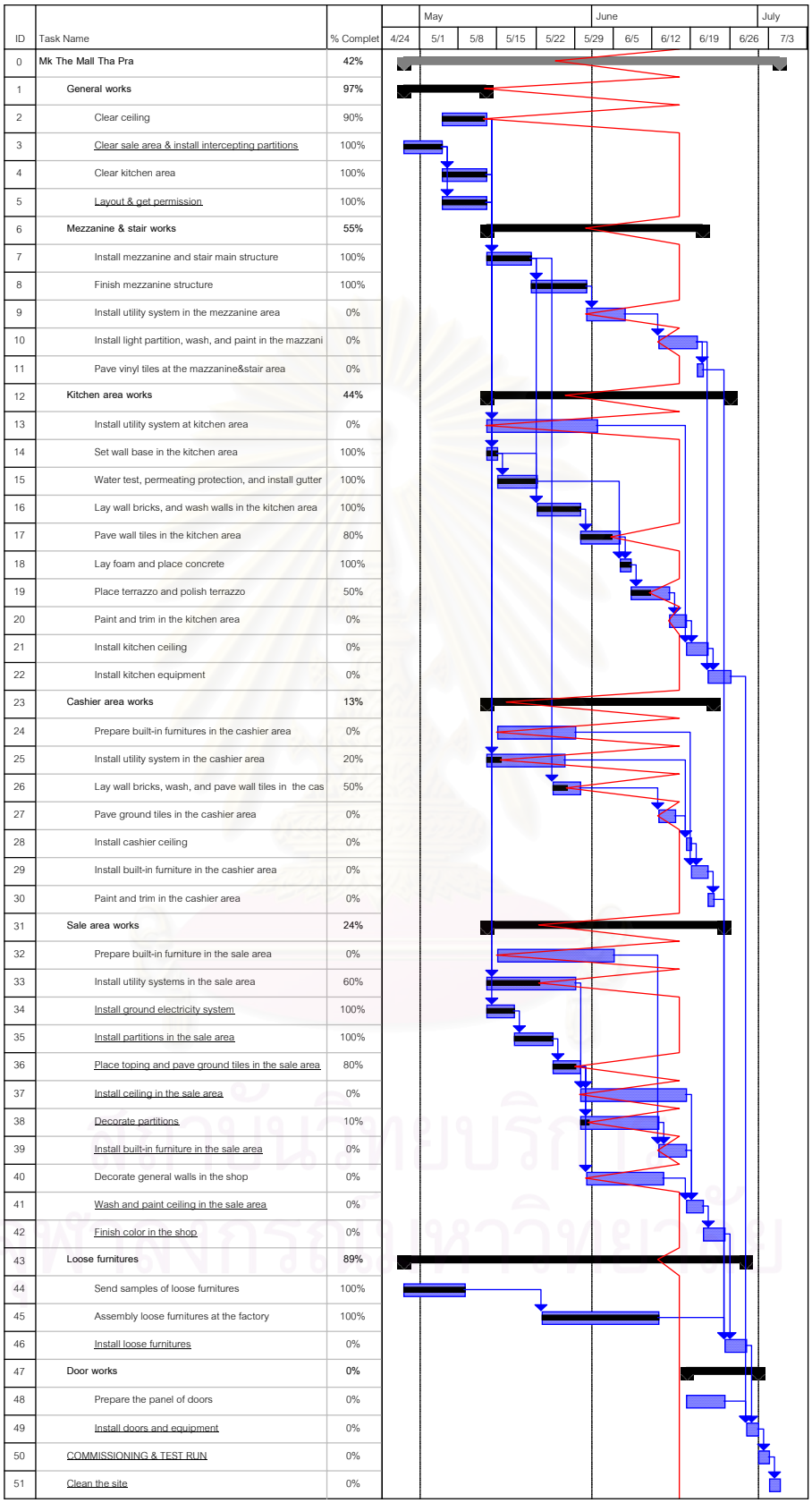
Figure 5-18: Two types of the partition decoration grouped by materials

In regard to the loose furniture, assembling the loose furniture had been finished at the factory of the company as shown in figure 5-19.

Figure 5-19: The photos of the project site as at June 16, 2000

Loose furniture at the factory

Figure 5-19: The photos of the project site as at June 16, 2000 (Continued)



ID	Task Name	% Complet
0	**Mk The Mall Tha Pra**	**42%**
1	**General works**	**97%**
2	Clear ceiling	90%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	**Mezzanine & stair works**	**55%**
7	Install mezzanine and stair main structure	100%
8	Finish mezzanine structure	100%
9	Install utility system in the mezzanine area	0%
10	Install light partition, wash, and paint in the mazzani	0%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	**Kitchen area works**	**44%**
13	Install utility system at kitchen area	0%
14	Set wall base in the kitchen area	100%
15	Water test, permeating protection, and install gutter	100%
16	Lay wall bricks, and wash walls in the kitchen area	100%
17	Pave wall tiles in the kitchen area	80%
18	Lay foam and place concrete	100%
19	Place terrazzo and polish terrazzo	50%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	**Cashier area works**	**13%**
24	Prepare built-in furnitures in the cashier area	0%
25	Install utility system in the cashier area	20%
26	Lay wall bricks, wash, and pave wall tiles in the cas	50%
27	Pave ground tiles in the cashier area	0%
28	Install cashier ceiling	0%
29	Install built-in furniture in the cashier area	0%
30	Paint and trim in the cashier area	0%
31	**Sale area works**	**24%**
32	Prepare built-in furniture in the sale area	0%
33	Install utility systems in the sale area	60%
34	Install ground electricity system	100%
35	Install partitions in the sale area	100%
36	Place toping and pave ground tiles in the sale area	80%
37	Install ceiling in the sale area	0%
38	Decorate partitions	10%
39	Install built-in furniture in the sale area	0%
40	Decorate general walls in the shop	0%
41	Wash and paint ceiling in the sale area	0%
42	Finish color in the shop	0%
43	**Loose furnitures**	**89%**
44	Send samples of loose furnitures	100%
45	Assembly loose furnitures at the factory	100%
46	Install loose furnitures	0%
47	**Door works**	**0%**
48	Prepare the panel of doors	0%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-20: The tracking chart as at June 16, 2000

5.6.8 The Project Progress as at June 23, 2000

The project progress as at June 23, 2000 can be seen in the photos of the project site as figure 5-21, and concluded as the tracking chart as figure 5-22. From the figure 5-21 & 5-22, the overall progress of the project was only 60%; whereas, the planed progress was 96%.

General Works and Mezzanine & Stair Works

At the tracking day, the existing AHU had been removed completely but it was removed rather difficult due to the installation of ceiling in the sale area as can be seen in figure 5-21. The installation of the metal structure of the ceiling in the sale area must left the area available to remove the existing AHU. However, it was still difficult. According to the mezzanine & Stair works, after finishing the mezzanine finishing the detail works of main structure of the mezzanine & stair since, in the last week, there is no progress in the utility installation in the mezzanine area. This was because the existing AHU still remained during the week.

Kitchen Area and Cashier Area Works

In the kitchen area, the terrazzo had been polished; whereas, the completeness of paving wall tiles in the kitchen were 90%. Whereas, there was still no progress in the utility installation in the kitchen.

According to the cashier area, the progress of the preparation of the built-in furniture in the cashier was about 85% at the factory and .the completeness of the utility system installation was about 40%. The wall and floor tiles had been paved, completely in the cashier area. In paving floor tiles in the cashier, it could be seen that the floor tiles must be paved from the sale area. They must be paved from the same direction. Thus, there was a mistake in the project network created in the planning due to the lack of experience of the researcher.

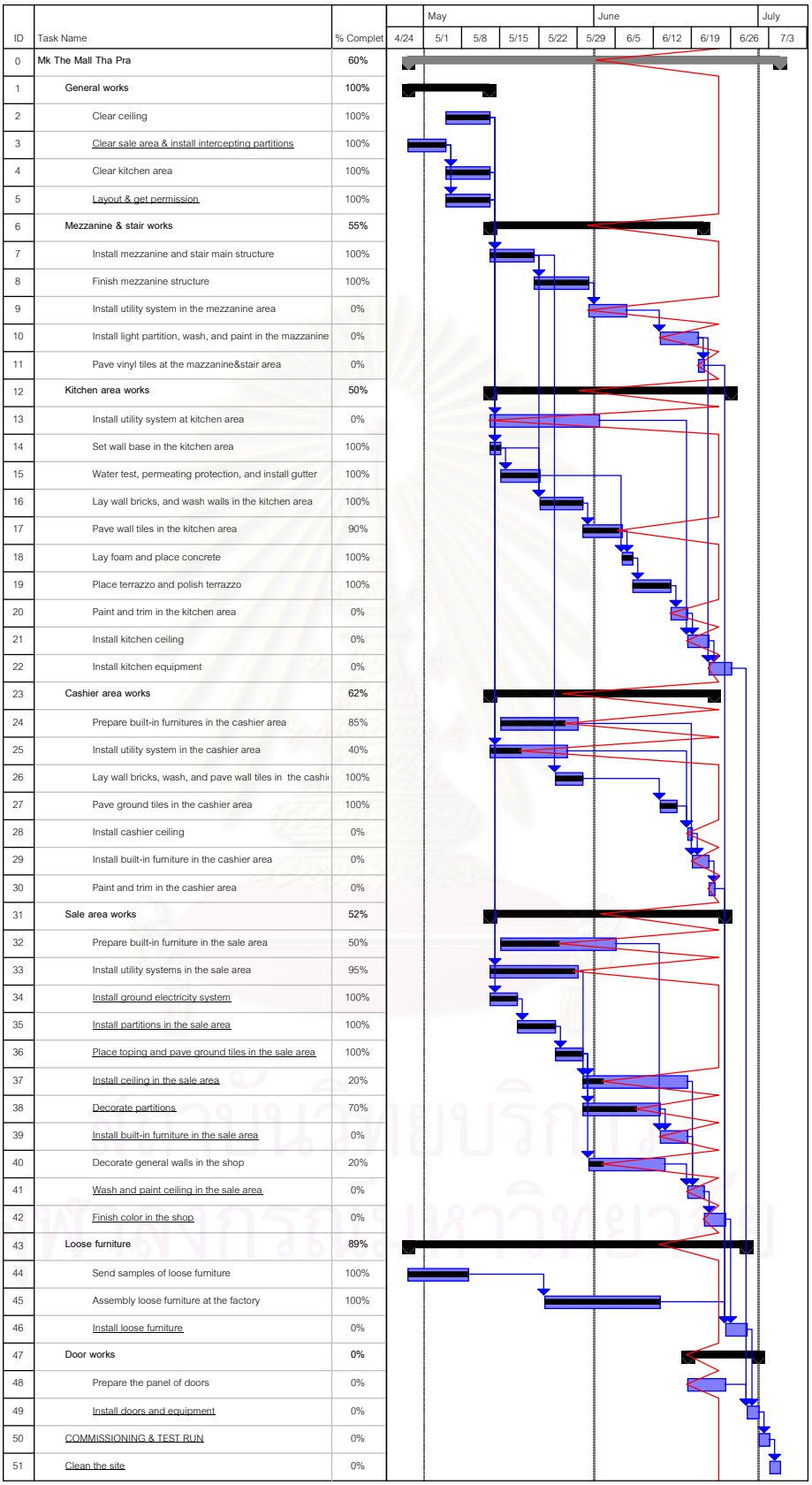
Sales Area Works and Door Works

In the sale area, the utility installation in the sale area had been completed about 95%; whereas, the progress of the ceiling installation was about 20%. Installing the metal structure was almost finished. And the completeness of the partition decoration was almost 70%. On Wednesday 21 June, the carpenters started to decorate the general wall in the sale area. Its progress was approximately 20% at the tracking date. In addition, the progress of the preparation of the built-in furniture in the sale area was nearly 50%. However, the panel of the doors had not been prepared yet.

Metal Structure

AHU

Figure 5-21: The photos of the project site as at June 23, 2000



ID	Task Name	% Complet
0	**Mk The Mall Tha Pra**	**60%**
1	**General works**	**100%**
2	Clear ceiling	100%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	**Mezzanine & stair works**	**55%**
7	Install mezzanine and stair main structure	100%
8	Finish mezzanine structure	100%
9	Install utility system in the mezzanine area	0%
10	Install light partition, wash, and paint in the mazzanine	0%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	**Kitchen area works**	**50%**
13	Install utility system at kitchen area	0%
14	Set wall base in the kitchen area	100%
15	Water test, permeating protection, and install gutter	100%
16	Lay wall bricks, and wash walls in the kitchen area	100%
17	Pave wall tiles in the kitchen area	90%
18	Lay foam and place concrete	100%
19	Place terrazzo and polish terrazzo	100%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	**Cashier area works**	**62%**
24	Prepare built-in furnitures in the cashier area	85%
25	Install utility system in the cashier area	40%
26	Lay wall bricks, wash, and pave wall tiles in the cashi	100%
27	Pave ground tiles in the cashier area	100%
28	Install cashier ceiling	0%
29	Install built-in furniture in the cashier area	0%
30	Paint and trim in the cashier area	0%
31	**Sale area works**	**52%**
32	Prepare built-in furniture in the sale area	50%
33	Install utility systems in the sale area	95%
34	Install ground electricity system	100%
35	Install partitions in the sale area	100%
36	Place toping and pave ground tiles in the sale area	100%
37	Install ceiling in the sale area	20%
38	Decorate partitions	70%
39	Install built-in furniture in the sale area	0%
40	Decorate general walls in the shop	20%
41	Wash and paint ceiling in the sale area	0%
42	Finish color in the shop	0%
43	**Loose furniture**	**89%**
44	Send samples of loose furniture	100%
45	Assembly loose furniture at the factory	100%
46	Install loose furniture	0%
47	**Door works**	**0%**
48	Prepare the panel of doors	0%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-22: The tracking chart as at June 23, 2000

The Project Progress as at 30 June 2000

The project progress as at 30 June 2000 can be seen in the photos of the project site as figure 5-23, and concluded as the tracking chart as figure 5-24. From the figure 5-23 & 5-24, the overall progress of the project was 74%; whereas, the planed progress was 99%.

Mezzanine & Stair Works

Although, the utility system installation had not been finished, some light partitions had been installed. However, the installation of the light partitions could be activated continually since some parts of the utility system, especially AHU, had not been installed or delivered yet. As it can be seen in the figure 5-23, the light partition in the front area could not be completed. There must be the space enough to lift the AHU in. Besides the lack of continuality in installing the light partition, the AHU was also hard to be installed because of the metal stud structure and the installed light partitions. In fact, the AHU installation will be more easily if the light partition and the ceiling are still not installed.

Kitchen Area and Cashier Area Works

In the kitchen area, paving wall tiles in the kitchen had been completed. Whereas, the progress of the utility installation in the kitchen was almost 30%.

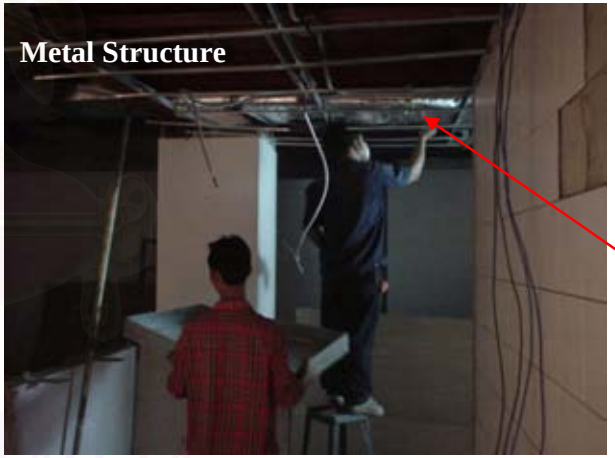
Regarding the cashier area, the utility system installation was completed almost 60%. Although, the utility installation had not been finished, the ceiling metal structure had been being installed. Actually, the ceiling in this area including closing the ceiling panel can be installed by using only 1-day duration. But, in this situation, after installing metal structure, the activity must be waited for the utility installation. In addition, the built-in furniture had been installed in the cashier area as shown in figure 5-23.

Sales Area Works and Loose Furniture

In the sale area, 70% of the built-in furniture had been installed; whereas, the progress in preparing the built-in furniture was almost completed. The utility system on the ceiling of the sale area had been finished. The progress was about 40% for the ceiling installation, and 65% for decorating the general walls. Although, carpenters are needed in activating these two activities, the total number of carpenters during the week was only 7 less than the estimated number for 50%. There were only 3 carpenters installing the arch wooden structure of the ceiling as shown in figure 23. This was because there was a carpenter group leaving the project with some parts of their wage. The reason for this was still unclear. As a result, new carpenter group must be found. Actually, the new carpenter group had been employed in the next week. In addition, some loose furniture was delivered to the site.

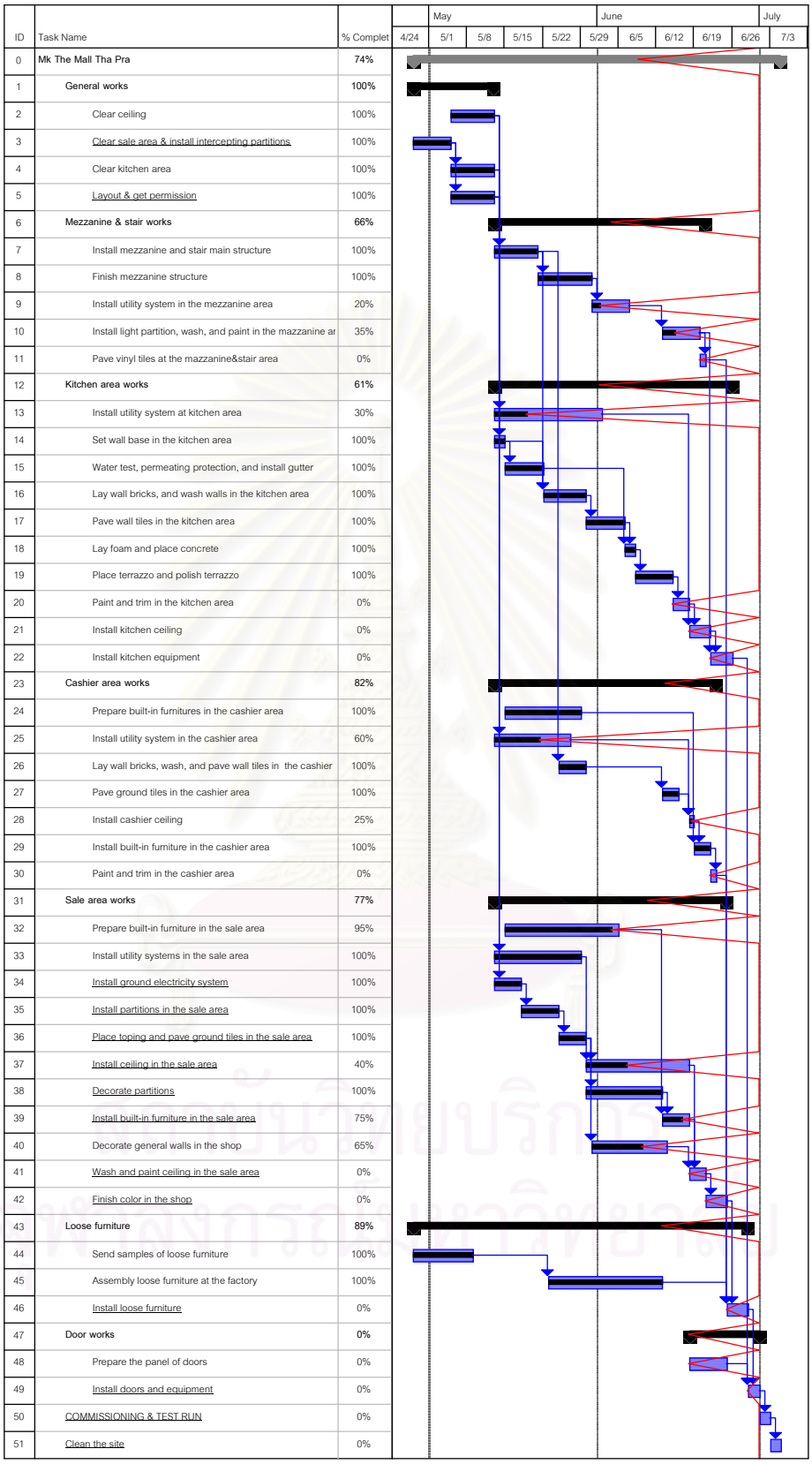
Figure 5-23: The photos of the project site as at 30 June 2000

Loose
Furniture



Flexible
Conduit

Figure 5-23: The photos of the project site as at 30 June 2000 (Continued)



ID	Task Name	% Complet
0	**Mk The Mall Tha Pra**	**74%**
1	**General works**	**100%**
2	Clear ceiling	100%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	**Mezzanine & stair works**	**66%**
7	Install mezzanine and stair main structure	100%
8	Finish mezzanine structure	100%
9	Install utility system in the mezzanine area	20%
10	Install light partition, wash, and paint in the mazzanine ar	35%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	**Kitchen area works**	**61%**
13	Install utility system at kitchen area	30%
14	Set wall base in the kitchen area	100%
15	Water test, permeating protection, and install gutter	100%
16	Lay wall bricks, and wash walls in the kitchen area	100%
17	Pave wall tiles in the kitchen area	100%
18	Lay foam and place concrete	100%
19	Place terrazzo and polish terrazzo	100%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	**Cashier area works**	**82%**
24	Prepare built-in furnitures in the cashier area	100%
25	Install utility system in the cashier area	60%
26	Lay wall bricks, wash, and pave wall tiles in the cashier	100%
27	Pave ground tiles in the cashier area	100%
28	Install cashier ceiling	25%
29	Install built-in furniture in the cashier area	100%
30	Paint and trim in the cashier area	0%
31	**Sale area works**	**77%**
32	Prepare built-in furniture in the sale area	95%
33	Install utility systems in the sale area	100%
34	Install ground electricity system	100%
35	Install partitions in the sale area	100%
36	Place toping and pave ground tiles in the sale area	100%
37	Install ceiling in the sale area	40%
38	Decorate partitions	100%
39	Install built-in furniture in the sale area	75%
40	Decorate general walls in the shop	65%
41	Wash and paint ceiling in the sale area	0%
42	Finish color in the shop	0%
43	**Loose furniture**	**89%**
44	Send samples of loose furniture	100%
45	Assembly loose furniture at the factory	100%
46	Install loose furniture	0%
47	**Door works**	**0%**
48	Prepare the panel of doors	0%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-24: The tracking chart as at June 30, 2000

5.6.8 The Project Progress as at July 7, 2000

The project progress as at July 7, 2000 can be seen in the photos of the project site as figure 5-25, and concluded as the tracking chart as figure 5-26. From the figure 5-25 & 5-26, the overall progress of the project was 85%; whereas, according to the plan, the project should be finished.

Mezzanine & Stair Works

The progress of the utility system installation was about 60%, while the completeness of the light partitions was almost 75%. From the figure 5-25, it could be seen that the utility installation was rather difficult due to the installed partition. To deliver the conduit, a metal bar was welded to the stair structure to aid balancing. On the other hand, finishing the light partitions also could not be done easily since the utility installation was not completed. Sometime, the light partitions were perforated to installed the conduit as seen in the figure 5-25. Their operations were obstacles with each other. This will not occur if the utility system is installed before the installation of the light partitions.

Kitchen Area and Cashier Area Works

In the kitchen area, the progress of the utility installation was 65%, approximately; whereas, there was no development in other activities in the kitchen. According to the cashier area, the utility system installation was completed almost 80%, while there was no development in other activities.

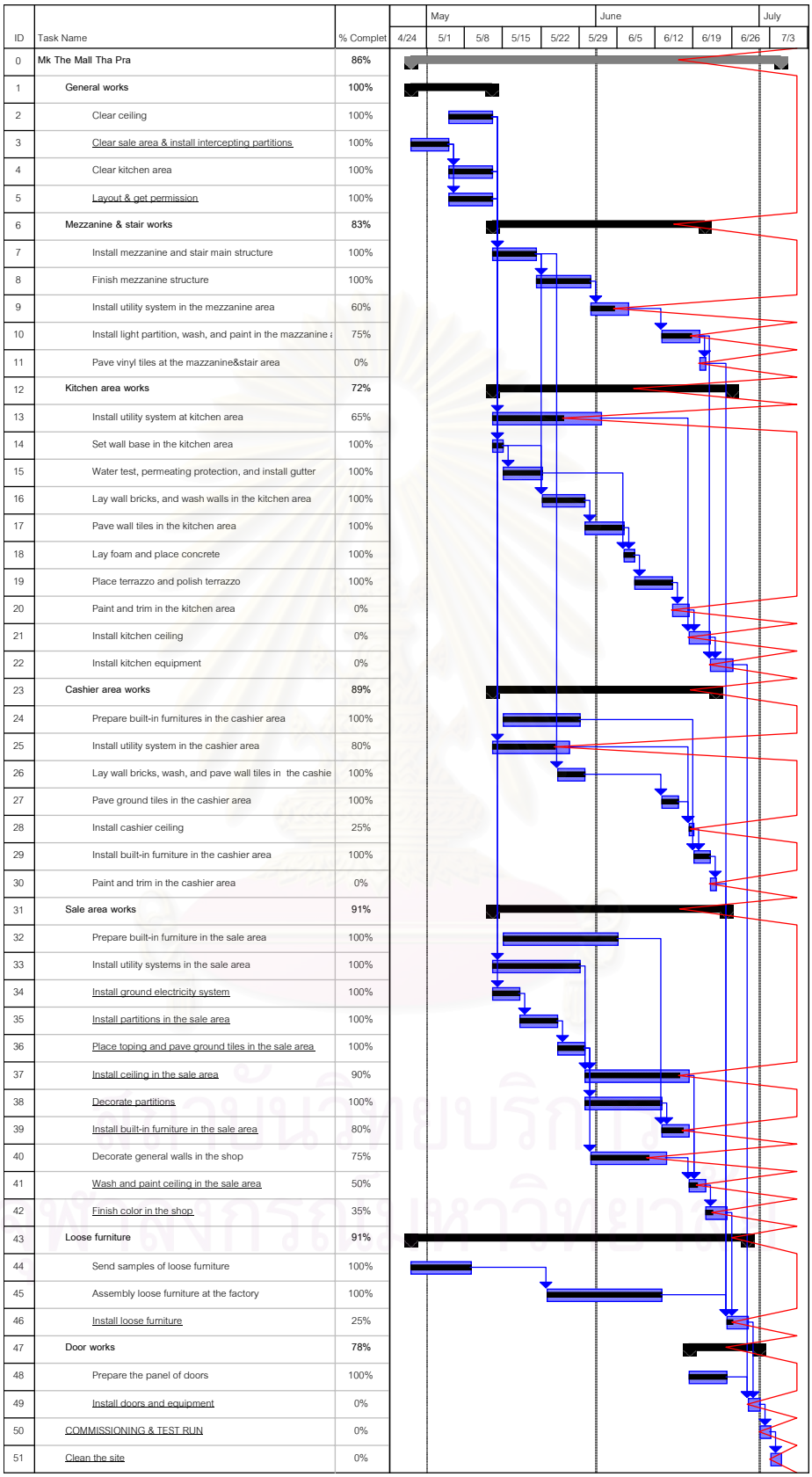
Sales Area Works, Loose furniture, and Door Works

In the sale area, the progress was about 90% for the ceiling installation, and 75% for decorating the general walls. The progress of the built-in furniture installation was about 80%. The completeness of the color of the ceiling in the sale area was almost 50%; whereas, it was completed about 35% for the color in the shop. The progress in installing the loose furniture was 25% and the door panel had been prepared at the factory.

From the observation, installing, washing, and painting the ceiling in the sale area, even though, applied many scaffolds, there was few protection on the floor. This was because there was no time available from reworks on the floor. One of the principal causes leading to the reworks is because there were many reference lines in the site. When a subcontractor group entered the site at the first time, a reference line was made. But when another one entered the site, a new one was made. As a result, there were many reference lines. The works were not at the same level. They were out of shape. This illustrated that standardization had not been made among the subcontractor's group. Moreover, without the floor protection, the damage to the floor tile will occur, and there may be reworks, again.

Figure 5-25: The photos of the project site as at July 7, 2000

Figure 5-25: The photos of the project site as at July 7, 2000 (Continued)



ID	Task Name	% Complet
0	**Mk The Mall Tha Pra**	**86%**
1	**General works**	**100%**
2	Clear ceiling	100%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	**Mezzanine & stair works**	**83%**
7	Install mezzanine and stair main structure	100%
8	Finish mezzanine structure	100%
9	Install utility system in the mezzanine area	60%
10	Install light partition, wash, and paint in the mazzanine a	75%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	**Kitchen area works**	**72%**
13	Install utility system at kitchen area	65%
14	Set wall base in the kitchen area	100%
15	Water test, permeating protection, and install gutter	100%
16	Lay wall bricks, and wash walls in the kitchen area	100%
17	Pave wall tiles in the kitchen area	100%
18	Lay foam and place concrete	100%
19	Place terrazzo and polish terrazzo	100%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	**Cashier area works**	**89%**
24	Prepare built-in furnitures in the cashier area	100%
25	Install utility system in the cashier area	80%
26	Lay wall bricks, wash, and pave wall tiles in the cashie	100%
27	Pave ground tiles in the cashier area	100%
28	Install cashier ceiling	25%
29	Install built-in furniture in the cashier area	100%
30	Paint and trim in the cashier area	0%
31	**Sale area works**	**91%**
32	Prepare built-in furniture in the sale area	100%
33	Install utility systems in the sale area	100%
34	Install ground electricity system	100%
35	Install partitions in the sale area	100%
36	Place toping and pave ground tiles in the sale area	100%
37	Install ceiling in the sale area	90%
38	Decorate partitions	100%
39	Install built-in furniture in the sale area	80%
40	Decorate general walls in the shop	75%
41	Wash and paint ceiling in the sale area	50%
42	Finish color in the shop	35%
43	**Loose furniture**	**91%**
44	Send samples of loose furniture	100%
45	Assembly loose furniture at the factory	100%
46	Install loose furniture	25%
47	**Door works**	**78%**
48	Prepare the panel of doors	100%
49	Install doors and equipment	0%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-26: The tracking chart as at July 7, 2000

5.6.8 The Project Progress as at July 14, 2000

The project progress as at July 14, 2000 can be seen in the photos of the project site as figure 5-27, and concluded as the tracking chart as figure 5-28. From the figure 5-27 & 5-28, the overall progress of the project was 92%.

Mezzanine & Stair Works

The progress of the utility system installation was about 85%, while the completeness of the light partitions was almost 85%.

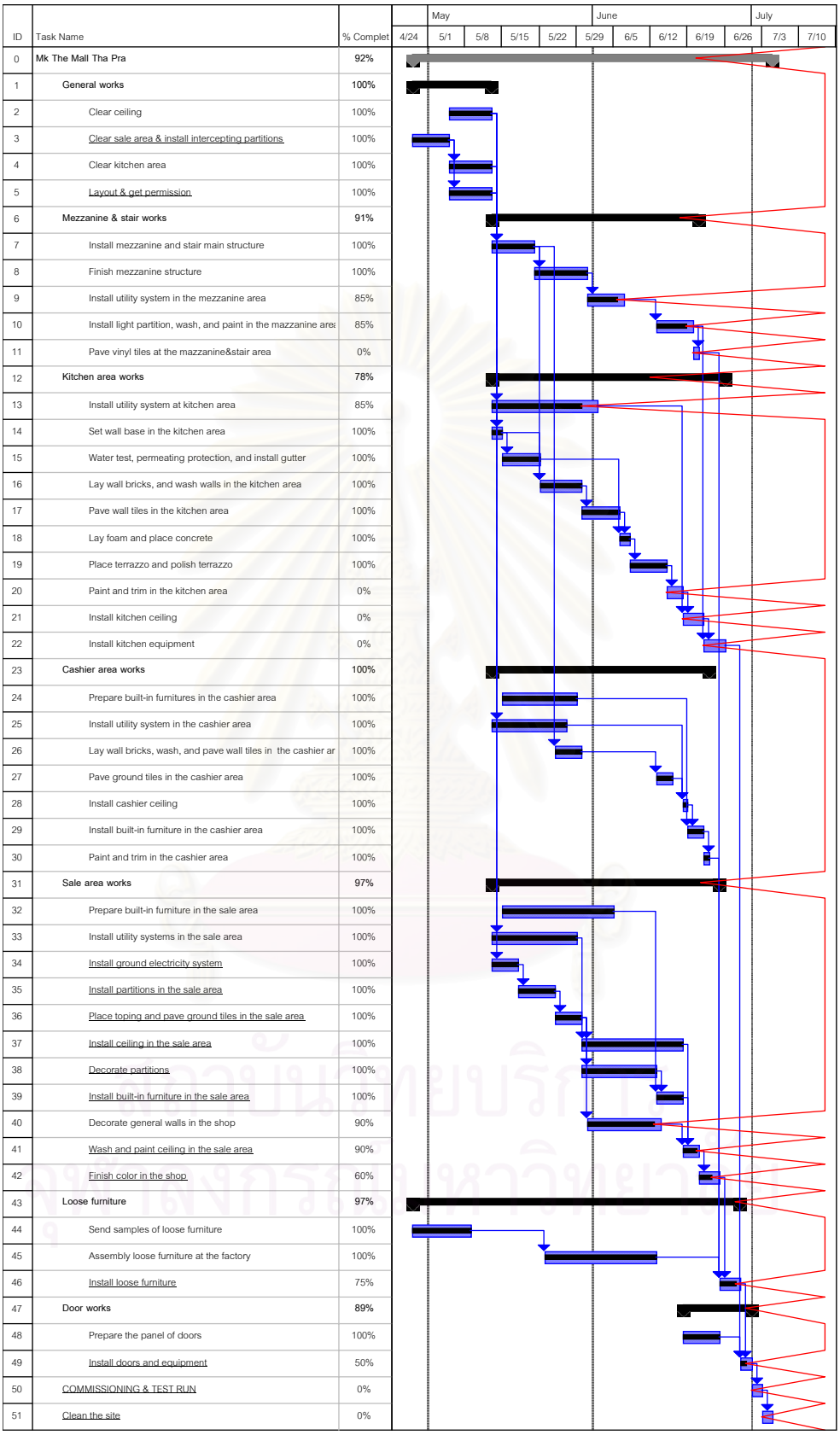
Kitchen Area and Cashier Area Works

In the kitchen area, the progress of the utility installation was about 85% as in the figure 5-27; whereas, there was still no development in other activities in the kitchen. According to the cashier area, at the end of the tracking day, this area was almost finished. The last activity in this area was to paint in this area as shown in figure 5-27.

Sales Area Works, Loose furniture, and Door Works

In the sale area, the ceiling and the built-in furniture installation were completed. Decorating the general walls had been done about 90%. The completeness of the color of the ceiling in the sale area was almost 90%; whereas, it was completed about 60% for the color in the shop. The progress in installing the loose furniture was 75% and the doors had been installed 50%.

Figure 5-27: The photos of the project site as at July 14, 2000



ID	Task Name	% Complet
0	**Mk The Mall Tha Pra**	**92%**
1	**General works**	**100%**
2	Clear ceiling	100%
3	Clear sale area & install intercepting partitions	100%
4	Clear kitchen area	100%
5	Layout & get permission	100%
6	**Mezzanine & stair works**	**91%**
7	Install mezzanine and stair main structure	100%
8	Finish mezzanine structure	100%
9	Install utility system in the mezzanine area	85%
10	Install light partition, wash, and paint in the mazzanine area	85%
11	Pave vinyl tiles at the mazzanine&stair area	0%
12	**Kitchen area works**	**78%**
13	Install utility system at kitchen area	85%
14	Set wall base in the kitchen area	100%
15	Water test, permeating protection, and install gutter	100%
16	Lay wall bricks, and wash walls in the kitchen area	100%
17	Pave wall tiles in the kitchen area	100%
18	Lay foam and place concrete	100%
19	Place terrazzo and polish terrazzo	100%
20	Paint and trim in the kitchen area	0%
21	Install kitchen ceiling	0%
22	Install kitchen equipment	0%
23	**Cashier area works**	**100%**
24	Prepare built-in furnitures in the cashier area	100%
25	Install utility system in the cashier area	100%
26	Lay wall bricks, wash, and pave wall tiles in the cashier ar	100%
27	Pave ground tiles in the cashier area	100%
28	Install cashier ceiling	100%
29	Install built-in furniture in the cashier area	100%
30	Paint and trim in the cashier area	100%
31	**Sale area works**	**97%**
32	Prepare built-in furniture in the sale area	100%
33	Install utility systems in the sale area	100%
34	Install ground electricity system	100%
35	Install partitions in the sale area	100%
36	Place toping and pave ground tiles in the sale area	100%
37	Install ceiling in the sale area	100%
38	Decorate partitions	100%
39	Install built-in furniture in the sale area	100%
40	Decorate general walls in the shop	90%
41	Wash and paint ceiling in the sale area	90%
42	Finish color in the shop	60%
43	**Loose furniture**	**97%**
44	Send samples of loose furniture	100%
45	Assembly loose furniture at the factory	100%
46	Install loose furniture	75%
47	**Door works**	**89%**
48	Prepare the panel of doors	100%
49	Install doors and equipment	50%
50	COMMISSIONING & TEST RUN	0%
51	Clean the site	0%

Figure 5-28: The tracking chart as at July 14, 2000

5.6.9 The Project Progress as at July 21, 2000

At the end of this tracking day, all activities had been completed; however, the subcontractors of the company were still needed to finished reworks and fix the defects as shown in figure 5-29. Since the planed finished date is 4 July 2000, this project has 17-day delay.

Figure 5-29: The photos of the project site as at July 21, 2000

Figure 5-29: The photos of the project site as at July 21, 2000 (Continued)

Chapter 6

Discussion and Evaluation

6.1 Introduction

In this chapter, the results of the proposed control system implemented in the case study project will be discussed. The discussion will, mainly, compare the actual results to the baseline plan. The discussion will be activated in three areas, the project schedule, the manpower, and the materials. After the discussion, the evaluation of the implementation will be discussed.

6.2 The Project Schedule

The project actual progress comparing to the planed progress, relating to the time can be shown as figure 6-1 and the actual duration, start date, and finished date comparing to the baseline plan for each activity can be illustrated in the tracking Gantt as figure 6-2. Its detail information can be summarized in the table 6-1.

From the figure 6-1, it can be seen that the project had started to delay from the baseline plan since May 12. In May 19, the project progress was increased, slightly, by only 1% from the completeness 12% of May 12. This delay was caused by 3 major reasons. First, there was the delay in starting the activities. From the table 6-1, after getting the layout permission for 3 days and 2 days, the iron structure and the ground electricity system installation was started, respectively. Whereas, during the week, there was no any progress in the utility installation on the ceiling of the sale area. Second, besides the delay of the started dates, there was also the lack of workforces. There were only 3 ironworkers in the iron structure installation. Moreover, there was also the 5-day stoppage of the ground electricity system installation due to the conflict in the material detail as mentioned in the chapter 5. After May 19, the progress of the project increased steadily by 6-8% per week until June 16; whereas, after June 16, the project progress had increased with the higher rate of 11-18% per week until July 7 that is 3-day delay date. And the project was finished at July 21, which made this project delay for 17 days.

These illustrate that the slack or float time had been burned out and over during the beginning of the project, and then, after realizing the project delay or closing the dead line, the project had been crashed. Unlike the baseline plan, the progress of the project should be increased with high rate at the beginning of the project and then the increasing rate will be reduced continually. However, the project was, although, be crashed, the project was not finished on time. The 17-day delay occurred.

To finish the project on time, crashing the project at the beginning stage of the project will be more considerable choice than crashing it at the middle stage or near the end of the project. The project should be crashed since the delay of the ground electricity was occurred. At the middle stage of the project, many groups and number of workforces must be involved as seen in the table 5-2. As a result, adding more workforces to crash the project may be limited by the site area. Moreover, to let the workforces work overtime will be more expensive due to the number of the involved workforces at that time.

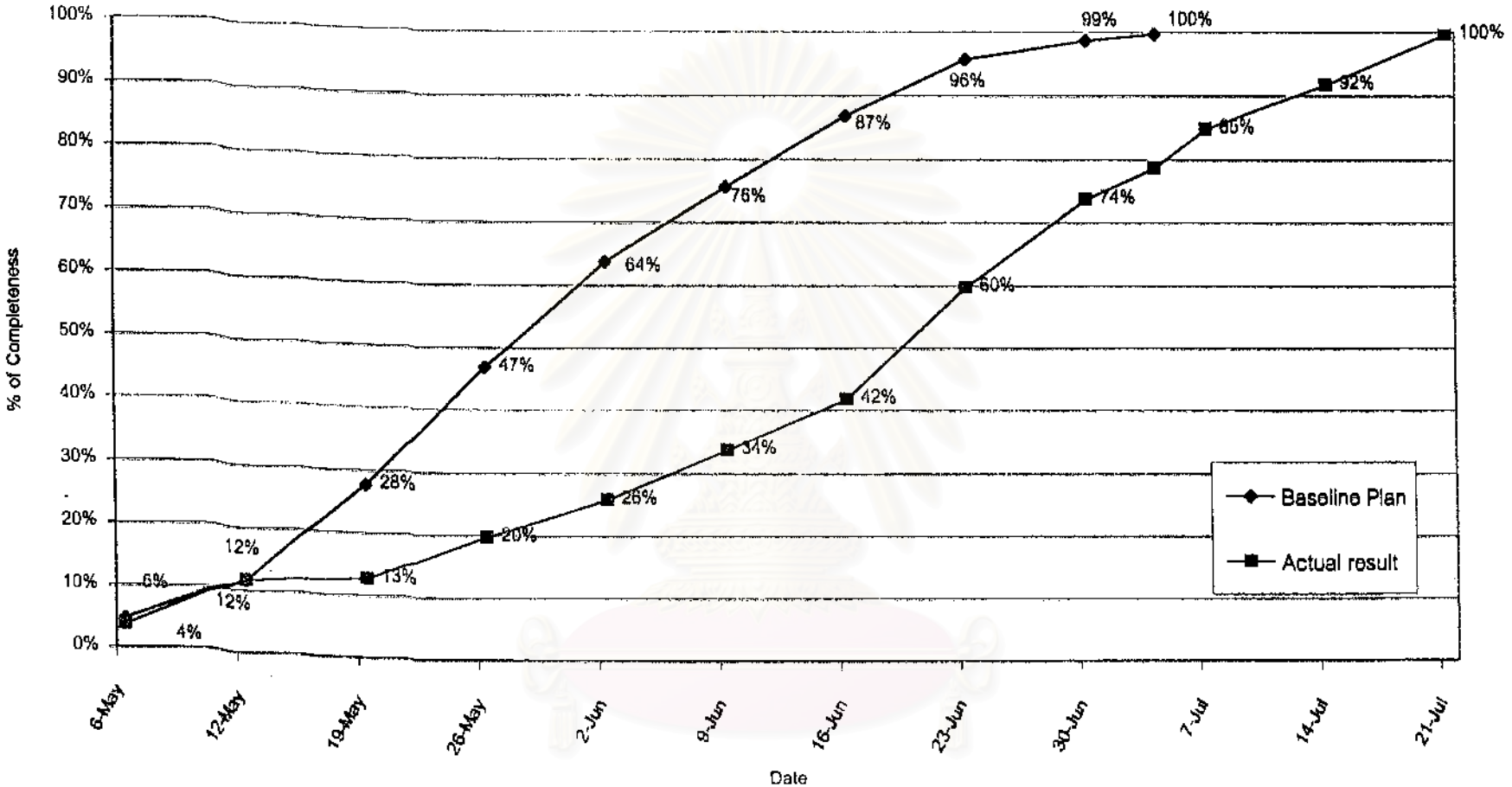


Figure 6-1: The actual progress comparing to the planed progress relating to the time

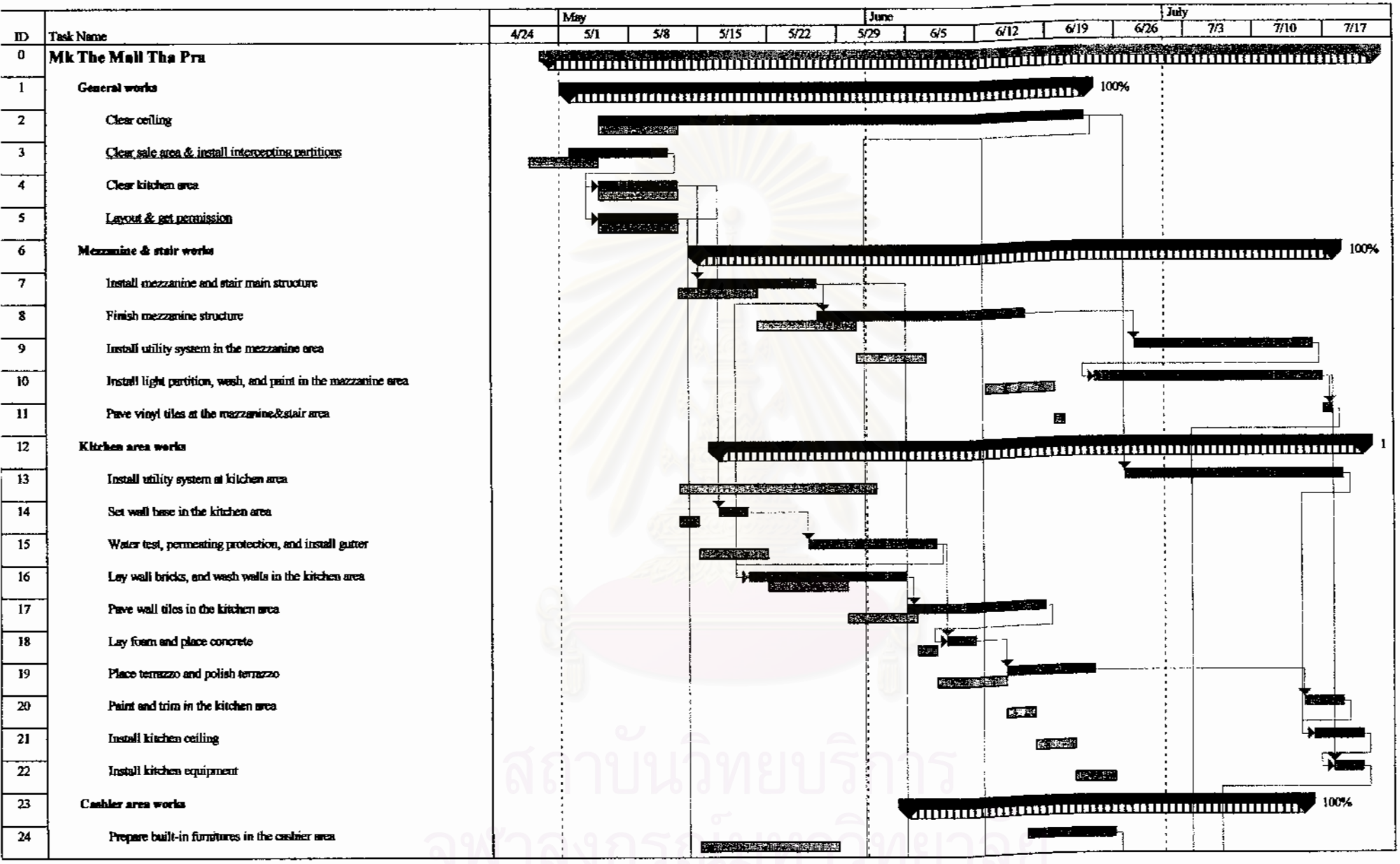


Figure 6-2: The tracking Gantt illustrating the duration of the actual result and the baseline plan for each activity

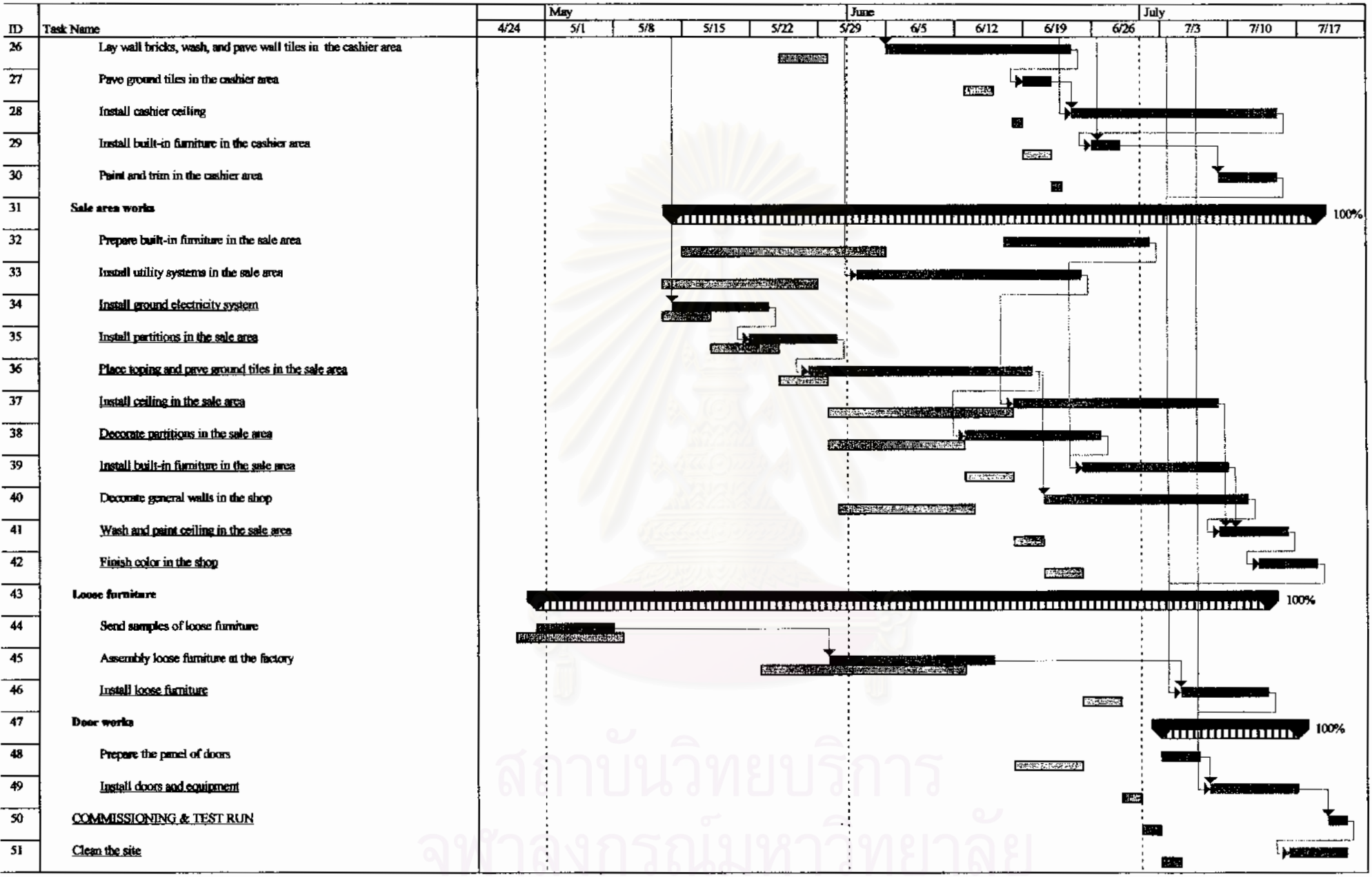


Figure 6-2: The tracking Gantt illustrating the duration of the actual result and the baseline plan for each activity (Continued)

ID	Task Name	Baseline Start	Actual Start	Start Variance	Baseline Finish	Actual Finish	Finish Variance	Baseline Duration	Actual Duration	Duration Variance
0	**Mk The Mall Tha Pra**	**Fri 4/28/00**	**Sun 4/30/00**	**2 days**	**Tue 7/4/00**	**Fri 7/21/00**	**17 days**	**67 days**	**82 days**	**15 days**
1	**General works**	**Fri 4/28/00**	**Tue 5/2/00**	**3 days**	**Fri 5/12/00**	**Thu 6/22/00**	**41 days**	**14 days**	**52 days**	**38 days**
2	Clear ceiling	Fri 5/5/00	Fri 5/5/00	0 days	Fri 5/12/00	Thu 6/22/00	41 days	8 days	49 days	41 days
3	Clear sale area & install intercepting partitions	Fri 4/28/00	Tue 5/2/00	3 days	Thu 5/4/00	Thu 5/11/00	7 days	6 days	10 days	4 days
4	Clear kitchen area	Fri 5/5/00	Fri 5/5/00	0 days	Fri 5/12/00	Fri 5/12/00	0 days	8 days	8 days	0 days
5	Layout & get permission	Fri 5/5/00	Fri 5/5/00	0 days	Fri 5/12/00	Fri 5/12/00	0 days	8 days	8 days	0 days
6	**Mezzanine & stair works**	**Sat 5/13/00**	**Mon 5/15/00**	**2 days**	**Tue 6/20/00**	**Mon 7/17/00**	**27 days**	**39 days**	**64 days**	**25 days**
7	Install mezzanine and stair main structure	Sat 5/13/00	Mon 5/15/00	2 days	Sat 5/20/00	Fri 5/26/00	6 days	8 days	12 days	4 days
8	Finish mezzanine structure	Sun 5/21/00	Sat 5/27/00	6 days	Tue 5/30/00	Fri 6/16/00	17 days	10 days	21 days	11 days
9	Install utility system in the mezzanine area	Wed 5/31/00	Wed 6/28/00	28 days	Tue 6/6/00	Sat 7/15/00	39 days	7 days	18 days	11 days
10	Install light partition, wash, and paint in the mazzanine area	Tue 6/13/00	Sat 6/24/00	11 days	Mon 6/19/00	Sun 7/16/00	27 days	7 days	23 days	16 days
11	Pave vinyl tiles at the mazzanine&stair area	Tue 6/20/00	Mon 7/17/00	27 days	Tue 6/20/00	Mon 7/17/00	27 days	1 day	1 day	0 days
12	**Kitchen area works**	**Sat 5/13/00**	**Wed 5/17/00**	**4 days**	**Sun 6/25/00**	**Thu 7/28/00**	**35 days**	**44 days**	**65 days**	**21 days**
13	Install utility system at kitchen area	Sat 5/13/00	Tue 6/27/00	45 days	Thu 6/1/00	Tue 7/18/00	47 days	20 days	22 days	2 days
14	Set wall base in the kitchen area	Sat 5/13/00	Wed 5/17/00	4 days	Sun 5/14/00	Fri 5/19/00	5 days	2 days	3 days	1 day
15	Water test, permeating protection, and install gutter	Mon 5/15/00	Fri 5/26/00	11 days	Sun 5/21/00	Wed 6/7/00	17 days	7 days	13 days	6 days
16	Lay wall bricks, and wash walls in the kitchen area	Mon 5/22/00	Sat 5/20/00	-2 days	Mon 5/29/00	Sun 6/4/00	6 days	8 days	16 days	8 days
17	Pave wall tiles in the kitchen area	Tue 5/30/00	Mon 6/5/00	6 days	Mon 6/5/00	Sun 6/18/00	13 days	7 days	14 days	7 days
18	Lay foam and place concrete	Tue 6/6/00	Fri 6/9/00	3 days	Wed 6/7/00	Sun 6/11/00	4 days	2 days	3 days	1 day
19	Place terrazzo and polish terrazzo	Thu 6/8/00	Thu 6/15/00	7 days	Wed 6/14/00	Fri 6/23/00	9 days	7 days	9 days	2 days
20	Paint and trim in the kitchen area	Thu 6/15/00	Sat 7/15/00	30 days	Sat 6/17/00	Tue 7/18/00	31 days	3 days	4 days	1 day
21	Install kitchen ceiling	Sun 6/18/00	Sun 7/16/00	28 days	Wed 6/21/00	Thu 7/20/00	29 days	4 days	5 days	1 day
22	Install kitchen equipment	Thu 6/22/00	Tue 7/18/00	26 days	Sun 6/25/00	Thu 7/20/00	25 days	4 days	3 days	-1 day
23	**Cashier area works**	**Sat 5/13/00**	**Mon 6/5/00**	**23 days**	**Thu 6/22/00**	**Fri 7/14/00**	**22 days**	**41 days**	**40 days**	**-1 day**
24	Prepare built-in furnitures in the cashier area	Mon 5/15/00	Sat 6/17/00	33 days	Sun 5/28/00	Sun 6/25/00	28 days	14 days	9 days	-5 days
25	Install utility system in the cashier area	Sat 5/13/00	Wed 6/14/00	32 days	Fri 5/26/00	Thu 7/13/00	48 days	14 days	30 days	16 days
26	Lay wall bricks, wash, and pave wall tiles in the cashier area	Thu 5/25/00	Mon 6/5/00	11 days	Mon 5/29/00	Fri 6/23/00	25 days	5 days	19 days	14 days
27	Pave ground tiles in the cashier area	Tue 6/13/00	Mon 6/19/00	6 days	Thu 6/15/00	Wed 6/21/00	6 days	3 days	3 days	0 days
28	Install cashier ceiling	Sun 6/18/00	Sat 6/24/00	6 days	Sun 6/18/00	Fri 7/14/00	26 days	1 day	21 days	20 days
29	Install built-in furniture in the cashier area	Mon 6/19/00	Mon 6/26/00	7 days	Wed 6/21/00	Wed 6/28/00	7 days	3 days	3 days	0 days

Table 6-1: The detail information of the actual project results and the baseline plan

ID	Task Name	Baseline Start	Actual Start	Start Variance	Baseline Finish	Actual Finish	Finish Variance	Baseline Duration	Actual Duration	Duration Variance
30	Paint and trim in the cashier area	Thu 6/22/00	Sun 7/9/00	17 days	Thu 6/22/00	Fri 7/14/00	22 days	1 day	6 days	5 days
31	**Sale area works**	**Sat 5/13/00**	**Sun 5/14/00**	**1 day**	**Sat 6/24/00**	**Tue 7/18/00**	**24 days**	**43 days**	**66 days**	**23 days**
32	Prepare built-in furniture in the sale area	Mon 5/15/00	Sat 6/17/00	33 days	Sun 6/4/00	Sat 7/1/00	27 days	21 days	15 days	-6 days
33	Install utility systems in the sale area	Sat 5/13/00	Fri 6/2/00	20 days	Sun 5/28/00	Sat 6/24/00	27 days	16 days	23 days	7 days
34	Install ground electricity system	Sat 5/13/00	Sun 5/14/00	1 day	Wed 5/17/00	Tue 5/23/00	6 days	5 days	10 days	5 days
35	Install partitions in the sale area	Thu 5/18/00	Mon 5/22/00	4 days	Wed 5/24/00	Tue 5/30/00	6 days	7 days	9 days	2 days
36	Place toping and pave ground tiles in the sale area	Thu 5/25/00	Sun 5/28/00	3 days	Mon 5/29/00	Mon 6/19/00	21 days	5 days	23 days	18 days
37	Install ceiling in the sale area	Tue 5/30/00	Sun 6/18/00	19 days	Sat 6/17/00	Sat 7/8/00	21 days	19 days	21 days	2 days
38	Decorate partitions in the sale area	Tue 5/30/00	Tue 6/13/00	14 days	Mon 6/12/00	Mon 6/26/00	14 days	14 days	14 days	0 days
39	Install built-in furniture in the sale area	Tue 6/13/00	Sun 6/25/00	12 days	Sat 6/17/00	Sun 7/9/00	22 days	5 days	15 days	10 days
40	Decorate general walls in the shop	Wed 5/31/00	Wed 6/21/00	21 days	Tue 6/13/00	Tue 7/11/00	28 days	14 days	21 days	7 days
41	Wash and paint ceiling in the sale area	Sun 6/18/00	Sun 7/9/00	21 days	Tue 6/20/00	Sat 7/15/00	25 days	3 days	7 days	4 days
42	Finish color in the shop	Wed 6/21/00	Thu 7/13/00	22 days	Sat 6/24/00	Tue 7/18/00	24 days	4 days	6 days	2 days
43	**Loose furniture**	**Fri 4/28/00**	**Sun 4/30/00**	**2 days**	**Wed 6/28/00**	**Thu 7/13/00**	**15 days**	**61 days**	**74 days**	**13 days**
44	Send samples of loose furniture	Fri 4/28/00	Sun 4/30/00	2 days	Mon 5/8/00	Sun 5/7/00	-1 day	10 days	7 days	-3 days
45	Assembly loose furniture at the factory	Tue 5/25/00	Tue 5/30/00	7 days	Mon 6/12/00	Thu 6/15/00	3 days	21 days	17 days	-4 days
46	Install loose furniture	Sun 6/25/00	Wed 7/5/00	10 days	Wed 6/28/00	Thu 7/13/00	15 days	4 days	9 days	5 days
47	**Door works**	**Sun 6/18/00**	**Mon 7/3/00**	**15 days**	**Fri 6/30/00**	**Sun 7/16/00**	**16 days**	**13 days**	**14 days**	**1 day**
48	Prepare the panel of doors	Sun 6/18/00	Mon 7/3/00	15 days	Sat 6/24/00	Thu 7/6/00	12 days	7 days	4 days	-3 days
49	Install doors and equipment	Thu 6/29/00	Sat 7/8/00	9 days	Fri 6/30/00	Sun 7/16/00	16 days	2 days	9 days	7 days
50	COMMISSIONING & TEST RUN	Sat 7/1/00	Thu 7/20/00	19 days	Sun 7/2/00	Fri 7/21/00	19 days	2 days	2 days	0 days
51	Clean the site	Mon 7/3/00	Sun 7/16/00	13 days	Tue 7/4/00	Fri 7/21/00	17 days	2 days	6 days	4 days

Table 6-1: The detail information of the actual project results and the baseline plan (Continued)

According to the figure 6-2, it could be seen that many activities had been activated while their predecessors had not been finished. In actual, these can be happened. Their relations may have lead times with one another. However, for this project, many activities could be, although, activated before their predecessors were finished or they were sometime being done at the same time, they tent to be obstacles with each other or cause the trouble. They might be done more difficultly. For example, the utility system installation was almost done parallel to the light partition installation in the mezzanine area. The conduits and AHU were delivered to the mezzanine floor difficultly; whereas, the delivery would be activated easier if the light partitions were not installed. The conduits and AHU could be lifted directly through the naked mezzanine structure. On the other hand, there were the excavations on the light partitions due to the conduit installation, causing the reworks on those partitions. In the sale area, the ceiling installation was, although, not finished, the loose furniture installation was begun. As a result, there were many scratches on the loose furniture caused by the scaffolds used in the ceiling installation as figure 6-3. The reworks were needed and, more time would be consumed. In addition, these parallel operations are a major cause leading to the high variance in the duration of each activity in the table 6-1.

Beside the parallel operations, from the figure 6-2, it can be also concluded that the project coordination was poor. This can be observed clearly by considering “clearing ceiling” and “utility installation” activities. The existing AHU still remained until June 22; whereas, the mezzanine structure had been finished since June 16. 6 days were lost unnecessarily to install the utility system on the mezzanine floor. Moreover, the existing AHU had been, although, removed since June 22, the utility system installation was begun in June 24. This was more 2-day loss. According to the utility installation in other areas, from the figure 6-2, it can be seen that most of them had burned all and over their slack or float time at the beginning of the project. They had finished not too much from the project’s completed date.

Figure 6-3: The scratch on the loose furniture

In regard to the table 6-1, regardless of clearing ceiling and laying wall bricks in the kitchen, the start variances of all activities are much surplus. This illustrates the unreliability of the project schedule. Whereas, the duration variances of many activities were surplus. Besides the parallel operations mentioned above, there are more three major causes leading to the surplus of the duration variance as follows:

1. There was less number of workforces than the expected number of workforces operating the activity. For example, there were only 3 ironworkers installing the mezzanine main structure; whereas, in regard to the plan, this task must be activated by 7 ironworkers for 8 days. As a result, the main structure installation was completed in 12 days. The duration variance for this activity is 4 days. Moreover, there was even the carpenter group leaving the project with some part of their wage.

2. The longer duration was due to the area limitation. Since the project site is on the second floor of the operating department store, the project site was limited by the given area, only about 410 square meters. Every materials needed in the day time operations must be delivered to the 410 m^2 site in the nigh. The large amount of materials could obstruct the daytime operation. The obvious case for this is also the floor tile pavement in the sale area, whose all tile boxes obstructed the ground tile pavement. To continue the operation, the tile boxes must be rearranged many times.

3. There were many reworks. The unexpected reworks always lead to the lack of workforces since some resources needed to be allocated to do reworks. For example, there were no builders to pave the floor tiles since they must be allocated to do the reworks of the partitions in the sale area.

6.3 Manpower

The actual number of workforces in each day can be illustrated as the table 6-2. Since the company outsourced the project operation to the subcontractors and there were no formal records of the company about the number of workforces in each day. The data in the table 6-2 are the estimated number collected by the researcher. To ease the estimation, there were three types of workforces recorded differently in the table.

1. The workforces that worked in the night shift. This type of workforces has equal working time to the daytime labor but their wage is 1.5 times to the daytime labor. All of them were used in clearing the site at the beginning of the project. The number of this workforce type will be *italic*.

2. The workforces that worked only on the daytime between 8.00 pm.-5.00 am. The number of this workforce type will be regular.

3. The workforces that worked on both the daytime and overtime. The working time for this labor type will be counted as 1.5 times to the daytime workforce; whereas, in the overtime, they will get wage rate at 1.5 times to the daytime rate. In one day, this workforce type will receive wage about 1.75 times of the daily wage of the workforce who works only on the daytime. The number of this workforce type will be <u>underlined</u>.

Type of Craftsman	เม.ย.-00			พ.ค.-00																													
	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Builder																		5	5	5	5	5	5	5	5	5	5	9	9	9	9	9	9	12
Stone worker																																		
Ceiling worker																																		
Painter																																		
Ironworker																		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Carpenter																																		
Stainless Worker																																		
Vinyl Tile Craftsman																																		
Others					10	10	10			10	14	14	8	8	8																			

Type of Craftsman	มิ.ย.-00																														ก.ค.-00			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4
Builder	12	20	12	12	12	15	20	20	20	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	10	10	8	10	10	8
Stone worker													4		4	4	4	9	4	4	4	4	4	4	4	4	4	4						
Ceiling worker																		5	5	4	4	4	4	4	5	5	5	5	5	7	7	2		
Painter																																		5
Ironworker	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3					2	3	3	3	3	3	3	3	3				3	3
Carpenter																					6	6	7	7	7	7	7	7	7	7	7	7	7	8
Stainless Worker												3	3	3	3	3	3											2	3	3	2	2		
Vinyl Tile Craftsman																																		
Others																																		

Type of Craftsman	ก.ค.-00																											ส.ค.-00						
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7
Builder	8			3		4		20	13	13	5					8	2																	
Stone worker						2																												
Ceiling worker	5	5		3	7	4	6	8	2																									
Painter	5	6	6		8	3	6	6	9	10	10	10	10	8	3	5	1																	
Ironworker	3	3																																
Carpenter	9	12	12	12		4	20	15	8	8	8	6	6			5																		
Stainless Worker			3	3	2																													
Vinyl Tile Craftsman											3																							
Others												8	8	4	3	3	6																	

Table 6-2: The actual number of workforces in each da

In fact, there would be the work situations that were out of these three types. The subcontractor might enter the project site lately and leave on time, or there might be the subcontractors that left the project after finishing their works at 3.00 am. However, due to the lack of the certain information about this point and to ease the calculation, the assumption about the three types of workforces will be applied in this thesis.

From the table 6-2, the differences in the total working time and the estimated total wage of each type of subcontractors between the actual result and the manpower plan can be summarized in table 6-3 by using the lowest wage rate in Thailand, bath 162 per day.

Subcontractor Types	Total working time (days)		% Variance	Estimated Total Wage (Baht)		% Variance
	Actual	Plan		Actual	Plan	
Builder	833	342	144%	148,574	55,746	167%
Stone worker	89.5	160	-44%	16,422	26,080	-37%
Ceiling worker	163.5	119	37%	30,603	19,397	58%
Painter	135.5	140	-3%	24,083	22,820	5.5%
Ironworker	155	126	23%	26,732	20,538	30.3%
Carpenter	304.5	304	0%	56,765	49,552	14.6%
Stainless Worker	53.5	70	-24%	9,984	11,410	-12.5%
Vinyl Tile Craftsman	4.5	4	13%	672	652	3%
Others	124	176	-30%	27,710	28,688	3.4%
Totals	1,863	1,441	29.29%	341,546	234,883	45.41%

Table 6-3: The differences in the total working time and the estimated total wage of each type of subcontractors between the actual result and the manpower plan

From the table 6-3, it can be seen that the actual total working days of the builders are about 833 working days, which are more than the manpower plan, 342 days, by 144%. Whereas, the estimated total actual wage of the builder subcontractor is bath 148,574 or more than the plan by 167%. These absolutely illustrate the big loss to the builder subcontractor. The major cause leading to these is because of the reworks that occurred in nearly every operation of the builders mentioned before. Moreover, from the observation and the table 6-2, the builders tent to burn out their float time at the beginning of the project. After realizing the delay of their operation and their reworks,

they tried to crash the project by increasing the number of workforces and overtime. However, the added number of the builders had rather low productivity due to the limitation of the site area and the material arrangement.

In regarding to the stone workers, the actual total working days of them tend to be lower than the manpower plan by nearly 50%. The major reason for this is due to the ambiguous action plan in the table 5-1. According to the action plan, the stone workers were assigned to do two activities at the same time: decorating the general walls and the partition in the sale area. The action plan illustrates that 4 stone workers must be allocated to decorate the partitions, and 5 stone workers must be allocated to decorate the partition in the sale area, which shows that at least 9 stone workers should be available. In fact, the stone works in these two activities are hard to divided with each other. They could be merged into only one activity. Moreover, during the duration of these two activities, the stone workers dose not need to be available until the end. They were applied only at the beginning of these two activities. In addition, this was also the reason for the stainless workers. They do not need to be available until the end of the general wall decoration.

For the ceiling workers, 37% more than the total working time of the manpower plan was due to the longer duration and reworks of the involved activity, caused by the parallel and wrong-sequence operations. Some installed parts of the ceiling must be cleared, cut, or removed to install the utility conduit. Some of them could not be finished because the utility installation was still not completed. There was the excavation on the ceiling or light partitions to install the utility conduit, leading to the reworks of the ceiling workers.

Despite of only 3 ironworkers, one of the major reasons leads to 23% more than the total working time of the manpower plan is due to the excluding an activity, the iron structure installation at the main entrance. Since, in the planning stage, this activity was considered to be included with the mezzanine structure installation. But from the observation, this activity should not be included because it actually affects more on the activities of the sale area than the mezzanine dose. Moreover, these two structures can be considered to be located in different work area.

About the others, the other subcontractor group has less the actual total working time than the manpower plan by 30%. This was, mainly, due to the over estimation in the duration and the workforce usage in clearing the site at the beginning of the project. However, the actual total working time is, although, less than the manpower plan by 30%, the actual total wage of the subcontractor group is estimated to be more than the manpower plan by 3.4%. This is also due to the work nature in clearing the site that can be activated only in the night shift leading to higher wage rate.

By the overall picture, the project tent to use the workforces more than the manpower plan by 29.29 %; whereas, the actual total wage was estimated to be about 45.41%. Actually, the company allocated about bath 400,000 as the budget for the labor costs. Thus, for this project, the profits gaining by the subcontractors of the company were only about bath 58,454 or only 15% of the allocated budget. Because the wage rate used to estimate the total wage is the lowest wage rate of Thailand. The subcontractors have rather the high risk to face the loss.

Since the company outsourced the operation to its subcontractors, many project managers thought that no more added costs was needed. All responsibility was delegated to the subcontractors. However, this idea is rather irresponsible and inconsiderable. In many cases, when the subcontractors face with the risk of loss, they just leave the project. And sometimes, they leave with some part of the wage. This may be the case for the

project that the carpenter group left the project with some part of the wage. The simple reason for this is a fundamental need of all subcontractors to make a profit on each project. Why should we do if the loss occurs? The effect on the short-term of this situation can be seen in the case study project. After the subcontractor left the project without notice, the project manager must find the other carpenter group as soon as possible to maintain the continuality of the project and finish it on time. This process normally consumes an amount of time. For this project, it was 7 days, which leads to the considerable risk to make the project delay. To find the new subcontractor to take over the operation as soon as possible, there were no much choices to be selected and be negotiated. As a result, the labor costs were increased, affecting the company directly.

Moreover, this event was also a significant cause that led to the 7-day delay of the project. For this project, the company assigned a project manager to take care the project in full time. And after realize the project delay, more 2 project managers were assigned to look after the project. The common wage of the project manager is about bath 12,000 per month. The 17-day delay of the project means the company must allocate its resources more than expected for 17 days. At least, one of these resources was three project managers. Thus, at least, the company must allocate their bath 20,400 resources more than expected to the project.

For the long-term effects, there will be fewer choices of the subcontractors. As the case of the builder subcontractor in this project, an amount of loss was absolutely occurred. A project manager expected that he would not accept this project type again. Because of the lack of subcontractor choices, the more this type of project passed, the more labor costs will be if the project is still managed in the same way. As a result, the company will lack the cost competitiveness since the project biding. On the other hand, if the project is activated smoothly with few reworks and with considerable coordination, the long-term relation between the company and the subcontractors can be developed with the win-win strategy. As a result, the more time passes, the more labor cost competitiveness of the company will be. Instead of a threat, the 45.51% in the table 6-3 can be changed to be an opportunity to make the company and its subcontractors gain profit together.

6.4 The Materials

According to the previous section, it can be seen that the project schedule developed from the action plan in chapter 5 is unreliable in the implementation. As a result, the material check sheets developed in the last section had rather few roles. There were, although, many revisions on the material check sheets regarding to the change in the project schedule. No any formal responses were fed back until when every activity was critical, the material check sheets were useless.

However, in this project, the material shortage did not occur obviously, but the more critical problem was the high level of the inventory. Because of the site constrains, most of material items that the company must procure were, firstly, delivered to the factory before delivering to the project site; even though, there were no material operation at the factory. These also cause high delivery costs. To reduce the delivery cost, a large amount of materials should be delivered as much as possible. However, due to the limitation of the project site area and the delivery time, locating the materials in the project site can cause the problem in activating the operation as mentioned before. This was always the trade-off decision through the project. Moreover, many items used to

prepare the built-in furniture and loose furniture were ordered to the factory at the beginning of the project. And those materials were operated after the procurement for 4-5 weeks.

To relieve the material problem for the project, preparing or renting the project warehouse near the project site may be a reasonable choice. The materials can be delivered to and stocked in the warehouse at the daytime, and deliver to the site in the night. Not too many material items will be stocked at the project site, causing no activity stoppage due to the material. The suppliers can send the material to the site on the daytime. The materials that have no transformation process at the factory can be delivered to the project warehouse. There were no needs to stock them at the factory. As a result, the inventory level at the factory will be reduced.

6.5 Evaluation

The implementation of the proposed control system in the case study project was rather unsuccessful due to its limitations in the system usage mentioned in the chapter 5. As discussed in the project schedule, the float or slack time had been burned out at the beginning stage. Nearly all activity had been started and finished delay from the baseline plan with rather high variances. Near the due date of the project, every task tent to be critical. As a result, the case study project was delay for 17 days.

There are 3 major causes leading to the limitation of the usage of the proposed project control system as follow:

1. It is due to the lack of the commitments to the proposed system from the involving groups. There are three factors leading to this cause. First, there was the lack of the communication between the company and its subcontractors. The project schedule was, although, illustrated to the subcontractors involving the project. No feedback came from the subcontractors' side. Second, the action plan developed in the chapter 5 was made by only the view of the interior decoration company. As a result, the action plan lacks the commitment from the other groups involving the project, especially from the consultant. Furthermore, there were less information details about other activities, which were under the responsibility of the other groups. As a result, the project coordination was poor. The agreement among the subcontractor groups was unclear. Finally, since the researcher was a full-time student, his role in controlling the project was low. After the project plan had been developed, he was almost a tracking person who examines the project progress in each week.

2. It is due to the lack of understand and familiarity with the proposed system of the involving individuals. The project managers and the involving individuals lack understanding about the network analysis. They are used to implementing the existing system to draw the bar chart manually, and then keep the plan in their heads. In addition, they are not used to reading the bar chart developed by MP98. They are used to read the bar or Gantt chart written manually. Thus, the usage of the proposed control system was limited.

3. It is due to the lack of studying the project before starting. No any site constraints and problems are mentioned before starting the project. As the result, the site constraints, site area, and delivery time, cause many problems in operating activities as mentioned in chapter 5. With the poor material management, the problem tent to be more critical, leading to the unexpected stoppages. Moreover, with the poor understand about the relations of activities in the project, there were many occurring reworks caused by the wrong activity sequence as mentioned in chapter 5. The reworks resulted in the unexpected time consumption and the unexpected resource allocation. From all mentioned above, many unexpected problems were occurred mostly every day. The reactive solutions done by the project manager are normally needed. As a result, even though, the project plan was always updated by applying the project management software, these make the project plan be unreliable and the proposed control system was considered to be too rigid.

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Chapter 7

Conclusion and Recommendation

Conclusion

This thesis aimed to reduce the delay and unnecessarily accelerated activities of the project by improving the project control system of an interior decoration company.

There are four major sections in this thesis. First section concerns the existing project control system of the interior decoration company. After making the contract, three major methods are applied. They are Gantt chart, site controlling, and account book tracking. Since they are all applied in the paper-based system, they are rather rigid to be changed and updated. As a result, informal methods are applied automatically, leading to the lack of coordination among involved groups, subcontractors, the procurement, and financial department. Because of the unclear agreements and the same commitment, the project tends to fail or delay.

The second section is the proposed project control system. The activity network of the interior decoration project is firstly discussed. And then, the proposed planning and control procedures are discussed briefly. Four stages in planning and control the project by applying the network analysis technique are introduced in the closed loop feedback control system. They are project planning, project scheduling, resource allocation, and project control. In project planning, all activities in the project will be listed. And then, the relations among them will be identified and the activity network will be developed to illustrated clear relation. Finally, the manpower and materials used in each activity will be planned. In addition, the forms of the action plan and the material check sheet were designed to aid the project planning. In the project scheduling, the project duration will be estimated. The forward and backward pass computations will be activated to find the early and late start and finish date for each activity. As a result, critical path, slack and float time for each activity can be illustrated. In resource allocation, the manpower will be smoothed and revised to not exceed the limitation. The procedure may be back to the first two stages many times in order to make the plan be possible. As a result of the stage, the project schedule and estimated manpower can be defined. Finally, the project plan developed in previous stages will be used in controlling the project in three major areas, the project progress relating to the planed schedule, the number of subcontractors at the site in each day, and the material and equipment preparation. Every stages mentioned above will have continuous relations until the project is finished. In the proposed project control system, a project management software, Microsoft's Project 98, is applied in the combination of the four mentioned stages to aid the calculation and to display the result.

The third section is the case study project that the proposed project control system was applied. The information about the project site is first introduced. And then, the proposed plan of the case study project are developed to control the project in three manners, the project schedule, manpower plan, and the material check sheets. However, the usage of the proposed project control system was limited by the familiarity of using the traditional manners and the lack of experience about the network analysis. Moreover,

there were also no commitments given by the other groups involving the project due to the poor communication. After tracking the project, it is found that the slack and float time of each activity was burned out at the early stage of the project. Low number of workforces is allocated to the project. Moreover, there were many reworks and activity stoppages occurring in the project due to the inconsiderable activity sequence. As a result, the project delayed for 17 days.

The last section is the discussion and evaluation of the proposed control system implementation in the case study project. The discussion is made through the three control areas, the project schedule, manpower, and the materials. From the analysis made through those areas, it is found that, beside 17-day delay of the project, nearly all activity had been started and finished delay from the baseline plan with rather high variance. The actual total working time was about 29.29% more than the planed time; whereas, the actual total wage cost was estimated to more than the plan 45.41%. The large proportion of this % consists mainly by the builder subcontractor whose actual total working time and wage were estimated to be over the plan by 144% and 167%, respectively. For the materials, since the proposed plan was unreliable, the developed material check sheets have rather few roles. The more time of the project pass, the fewer roles, they play.

From all mentioned above, it could be concluded that the implementation of the proposed project control systems is fail due to the limitation of the usage of the proposed project control system. There are 3 major causes leading to this limitation as follow:

1. The lack of the commitments to the proposed system from the involving groups due to poor communication with the other involving groups including the subcontractors and other involving groups, and the low role of the researcher in the case study project.

2. The lack of understand and familiarity with the proposed system of the involving individuals – the network analysis, and the computer usage.

3. The lack of studying the project before starting of the company – the site constraints and the details of other activities of other involving groups.

Recommendation

To reduce or to eliminate the delay for this type of the case study project, which consists of many involving groups, the recommendations are given as follows:

1. The communication and the coordination among the involving groups should be improved. The objective of the project must be clear. The relation of their activities with the activities taken care by the company should be declared clearly. To activate this, the network analysis technique, likes CPM or PCD, will be a useful communication tools. The project action plan should be developed through the discussions and the information from the involving groups. Regardless of the involvement in developing the action plan, no commitment will be provided as in

the case study project. Without the clear relation, conflicts among the activities tend to occur.

2. The company, although, outsources the project operation to the subcontractor, its main responsibility to the project failure or success still remains. When the project fails or delay, the reputation of the company will be degraded not the outsource subcontractor. Thus, when the company outsources the operation to the subcontractor, the subcontractor should do according to the company standard not their own standard, the small number of workforces they want to allocate, the skilled worker, and etc. The daily payment according to the state of completeness should be applied to maintain the number of subcontractor workforces. However, since the reliable subcontractors are normally hard to find, they should be treated as the company's resources. Win-win strategy should be applied to keep the long-term relation. If the reliable subcontractor always faces the situation like the builder subcontractor in the case study project they will not work with the company anymore. Or sometime, they will leave the project without notice causing the project delay.

3. The reworks should be minimized since the project planning. The reworks cause the unexpected time and resource consumption. They are difficult to manage when they occur. Many times, they can lead to the project delay since no enough workforces to operate other activities, especially, the activities on the critical path. For the example in the case study project, there were no builders to pave the ground tiles, which was a critical activity, because all the builders were allocated to do the reworks of the wall in the sale area. Moreover, the materials used in the reworks also obstacle the other activities, leading to the project delay. To minimize the reworks since the project planning, the considerable activity network should be developed to see the problems occurring by the relation of each activity. The top-down operation should be activated in order to generate not the damage to the floor and furniture.

4. Although, the network analysis technique is quite a useful tool in project planning and controlling, it could not be activated or applied by the only one individual. It should be activated by the skill team involving the project. Thus, to have an effective project control system, the network analysis training may be a reasonable investment.

5. The site constraint should be examined before starting the project. From the case study project, no any plans had been made to face with the site area and delivery time limitation. As a result, many materials were stocked at the project site and they cause the troubles in operating the activity.

From the suggestions mentioned before, the example of the proposed action plan of the case study project, which has the top-down operation, and the will to minimize reworks and to reduce the delay, can be illustrated as table 7-1. And its activity network in AON format can be shown in figure 7-1. To activate this proposed plan, there are some assumptions are made as follows:

1	Clear the site	4 days										16
2	Layout & get permission	2 days	1									
3	Install iron structures above the entrance	6 days	2					5				
4	Install utility system on the ceiling of the sale area	7 days	2									
5	Install ground wireway/conduit in the sale area	5 days	2									
6	Install partitions in the sale area	7 days	5	10								
7	Prepare built-in furniture in the sale area	9 days	6									
8	Install Stainless works in the sale area	7 days	6							5		
9	Install the ceiling in the sale area	18 days	4,3,6,24FF+1 day			5			6			
10	Pave ground tiles in the sale area	5 days	9	6								
11	Decorate walls and partitions in the sale area	14 days	10,8	8	4		8+9 days delay		8			
12	Install built-in furniture in the sale area	3 days	11,7						8			
13	Paint color in the sale area	3 days	12				10					
14	Install mezzanine and stair structure	18 days	2					4				
15	Install conduit at the cashier area	2 days	14									
16	Lay wall bricks, and wash in the cashier area	4 days	15	4								
17	Pave ground tiles in the cashier area	3 days	16,10	2								
18	Decorate wall in the cashier area	2 days	17	4								
19	Install the utility system on the ceiling of the cashier area	7 days	14									
20	Install the ceiling in the cashier area	1 day	18,19	2								
21	Prepare built-in furnitures in the cashier area	9 days	16									
22	Install built-in furniture in the cashier area	3 days	20,21		2				3			
23	Paint color in the cashier area	2 days	22				2					
24	Install the utility system in the kitchen, mezzanine & stair ar	10 days	14									
25	Install light partitions in the mezzanine & stair area	7 days	24			2	2					
26	Pave vinyl tiles at the mezzanine&stair area	1 day	25								4	
27	Set wall base in the kitchen area	2 days	2	5								
28	Lay wall bricks, and wash walls in the kitchen area	7 days	27,14	6								
29	Pave wall tiles in the kitchen area	7 days	28	4								
30	Water test, permeating protection, and install gutter	7 days	27	2								
31	Lay foam and place concrete	2 days	30,29	4								
32	Place terrazzo	1 day	31	4								
33	Polish terrazzo	1 day	32FS+5 days	4								
34	Paint color in the kitchen area	3 days	33				2					
35	Install kitchen ceiling	4 days	34			2						4
36	Install kitchen equipment	4 days	35						2			
37	Send samples of loose furniture	10 days										
38	Assembly loose furniture and door panels at the factory	21 days	37									
39	Install loose furnitures, doors, and equipment	3 days	38,13,23,36,26						10			
40	Commissioning & test run and clean the site	3 days	39									8

Table 7-1: The proposed action plan of the case study project

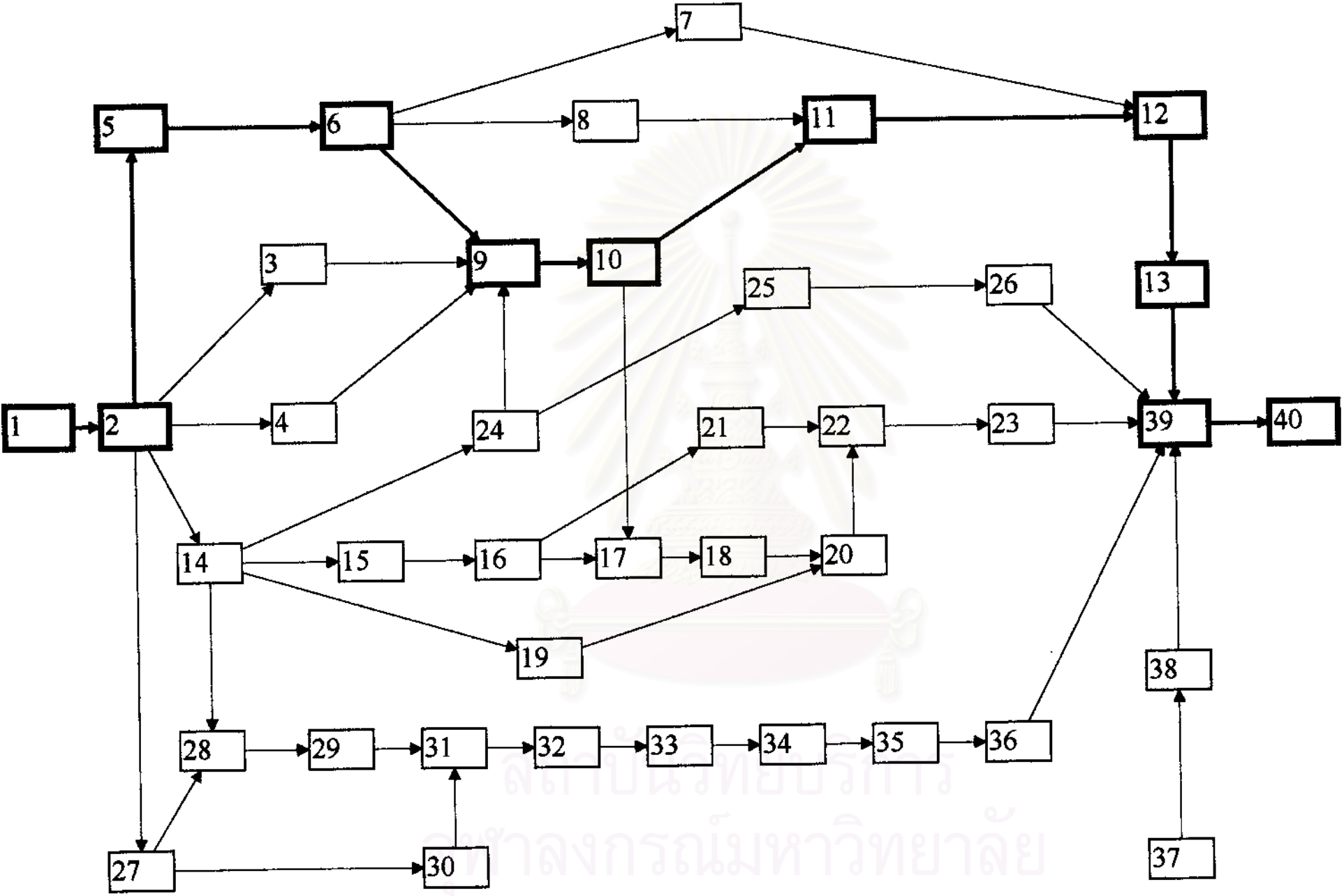

Figure 7-1: The activity network of the proposed plan in AON format

- There are the commitments from the involving groups including the consultant, the utility installation company, and etc.

- The existing toping of the site is reused to reduce the clearing activities and the trouble due to the site limitation.

- The excavation process is needed in the ground wire way/conduit to reduce the reworks caused by deleting the layout.

- There is a warehouse used to store the materials near the project site.

- The number of workforces is available not too much less than the proposed plan.

- The critical activities, 1, 2, 5, 6, 9, 10, 11, 12, 13, 39, and 40, must be controlled, closely, to be started and to be finished on the planed time.

From the table 7-1 and figure 7-1, it can be seen that the activity network is, although, presented in AON format, it cannot illustrated some assigned relations except finish-to-start relation clearly. For example, to finish the ceiling installation in the sale area, the utility installation in the mezzanine must be finished before for 1-day lag time. Thus, interpreting the network analysis displayed by MP98 must be activated carefully. The project plan developed in the previous section, although, applied the concept of CPM, Critical Path Method, directly, its development versions, like PCD, Precedence Diagram, may be used more effectively due to the hard-to-explain relations as mentioned above. Lag and lead-time may be used to explain these relations.

As the result of the proposed plan, the project should be finished on time and there should be the reduction in the total working time and the total wage of the subcontractors at the project site as in the table 7-2.

From the table 7-2, it can be seen that the overall working time should be reduced by 38%; whereas, the working time of the builders should be reduced by 59% from the actual usage. This will lead to the reduction in the total wage of the subcontractor about bath 150,000 or 44% of the actual total wage. In the other words, since the operations were outsourced, the subcontracts of the company can save or have more profits by bath 150,000. Anyway, this reduction can be treated as an opportunity of the company to share this benefit through better planning and controlling function. Moreover, the project will be also not delay. The company, at least, can save a resource, the project managers, needed to be allocated more due o the delay of the project as mentioned in the last chapter by baht 20,400.

Subcontractor Types	Total working time (days)		% Reduce	Estimated Total Wage (Baht)		% Reduce
	Actual	Proposed Plan		Actual	Proposed Plan	
Builder	833	344	59%	148,574	55,728	62%
Stone worker	89.5	70	22%	16,422	11,340	31%
Ceiling worker	163.5	114	30%	30,603	18,468	40%
Painter	135.5	91	33%	24,083	14,742	39%
Ironworker	155	102	34%	26,732	16,524	38%
Carpenter	304.5	291	4%	56,765	47,142	17%
Stainless Worker	53.5	35	35%	9,984	5,670	43%
Vinyl Tile Craftsman	4.5	4	11%	672	648	4%
Others	124	104	16%	27,710	22,032	20%
Totals	1,863	1,155	38%	341,546	192,294	44%

Table 7-2: The estimated reduction in the total working time and wage of the subcontractors due to the proposed plan

Due to the actual 17-day delay of the project, there is, although, the compromise since some unclear parts of this delay are caused by the utility installation company and other involving groups, the company must paid the fine for 7-day delay at the rate of bath 20,000 per days. This charged the company bath 140,000. Thus, if the proposed plan was activated, at least, the company could save directly bath 160,400.

However, because of the assumptions made in planning, there must be the commitments from involving groups. To apply this proposed plan in the real case project, the communication among involving groups will be a vital part in planning in order to get their commitments. The missing and detailing activities can be added, and revisions will be made many times to have a considerable and clear project plan.

In addition to the planning function of the company, the planning function, normally, begin after making the contract. However, many times, the customer wants the workforces to enter the project site by the tomorrow of the contract making day or as soon as possible. This always makes the project be the hurry job. No plan can be made on time, Sometimes, the subcontractors enter the work site without any plans and the materials used in the project tend to be hurry needed. As a result, no much time for the procurement department to compare the prices from many suppliers, leading to lack of cost competitiveness and corporation. In addition, in a considerable size project, the overall number of material items can be 60-70. To procure the all material items at the considerable price will be time-consumed tasks. Some errors can be happened, wrong price, incorrect dimension, and etc. To overcome these problems, the first 2 of 4 stages in the planning and control project introduced in the chapter 2 should be applied since the biding stage of the project.

The reason behind why the customers always want the project to be started in the tomorrow or as soon as possible is the on-time completion. They want the project to be finished on their needed or scheduled time. If the project scheduling had been done since the biding stage. The project duration can be estimated approximately. And then after making the contract, the resource allocation can be conducted suddenly in the reverse to the project scheduling. And then, the project plan can be delivered to the involving groups including the customer. By controlling the project on the schedule, the customer's on-time completion can be met. As a result, the rush project will be reduced, and with the formal communication, no much skill is needed to plan and control the project in the head. The cooperation among the involving group will be more considerable due to the same agreement. This will make the company be able to take care more projects with the same staff amount. The overhead cost will be shares more among many projects.

In regard to the material check sheets, the control level of each material will be defined by applying the Pareto principle. The material procurement will work more effectively since there will be about 10-20% of the total number of the project overall material items. Moreover, this control level of material can make the company have more cost competitiveness since the biding stage, because the major cost structure of the project materials is known. Only control 10-20% of the overall project materials can affect to the 80% of the overall material cost.

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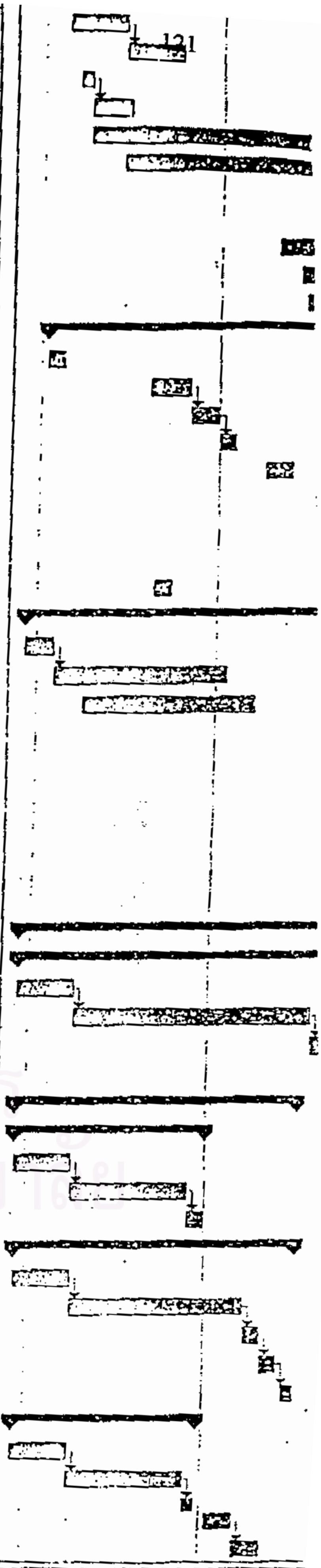
Appendices

Appendix A

		Duration	Start	Finish
	...แห่ง MK SUKI สาขาเดอะมอลล์ (ท่าพระ)	75 days	Fri 28/4/00	Tue 11/7/00
	1. งานทั่วไป	17 days	Fri 28/4/00	Sun 14/5/00
	1.1 งานตกแต่งภายใน	17 days	Fri 28/4/00	Sun 14/5/00
4	1.1.1 เตรียมงาน	12 days	Fri 28/4/00	Tue 9/5/00
5	1.1.2 สีฝัง	3 days	Sat 29/4/00	Mon 1/5/00
6	1.1.3 ตรวจรับและอนุมัติสีฝัง	1 day	Tue 2/5/00	Tue 2/5/00
7	1.1.4 อนุมัติวัสดุอุปกรณ์ทั้งหมด	17 days	Fri 28/4/00	Sun 14/5/00
8	1.2 ระบบไฟฟ้า	17 days	Fri 28/4/00	Sun 14/5/00
9	1.2.1 เตรียมงาน	12 days	Fri 28/4/00	Tue 9/5/00
10	1.2.2 อนุมัติวัสดุอุปกรณ์ทั้งหมด	17 days	Fri 28/4/00	Sun 14/5/00
11	1.3 งานระบบปรับและระบายอากาศ	17 days	Fri 28/4/00	Sun 14/5/00
12	1.3.1 เตรียมงาน	12 days	Fri 28/4/00	Tue 9/5/00
13	1.3.2 อนุมัติวัสดุอุปกรณ์ทั้งหมด	17 days	Fri 28/4/00	Sun 14/5/00
14	2. งานภายในครัว	35 days	Wed 3/5/00	Tue 6/6/00
15	2.1 งานตกแต่งภายใน	31 days	Wed 3/5/00	Fri 2/6/00
16	2.1.1 ทำแบบแปลนของงานครัว	3 days	Wed 3/5/00	Fri 5/5/00
17	2.1.2 TEST น้ำครั้งแรก	1 day	Sat 6/5/00	Sat 6/5/00
18	2.1.3 ทำกันซึมพื้น + ผนัง	1 day	Sun 7/5/00	Mon 7/5/00
19	2.1.4 TEST น้ำครั้งสุดท้าย	1 day	Mon 8/5/00	Mon 8/5/00
20	2.1.5 เทปูนทรายทับกันซึมที่พื้น	1 day	Tue 9/5/00	Tue 9/5/00
21	2.1.6 ติดตั้งราง GUTTER	2 days	Wed 10/5/00	Thu 11/5/00
	2.1.7 ปูโฟมและเทคอนกรีตพื้น	2 days	Mon 15/5/00	Tue 16/5/00
23	2.1.8 เทหินขัดและขัดหินพื้น	10 days	Wed 17/5/00	Fri 26/5/00
24	2.1.9 ก่ออิฐมอญและฉาบ	13 days	Tue 9/5/00	Fri 26/5/00
25	2.1.10 ปูกระเบื้องผนัง	7 days	Mon 15/5/00	Sun 21/5/00
26	2.1.11 ฉาบทาสี	5 days	Mon 22/5/00	Fri 26/5/00
27	2.1.12 งานฝ้าเพดาน	5 days	Mon 29/5/00	Fri 2/6/00
28	2.2 งานระบบไฟฟ้า	23 days	Mon 15/5/00	Tue 6/6/00
29	2.2.1 WIREWAY/CONDUIT	7 days	Mon 15/5/00	Sun 21/5/00
30	2.2.2 WIRING	5 days	Mon 22/5/00	Fri 26/5/00
31	2.2.3 SWITCH/OUTLET	3 days	Sat 27/5/00	Mon 29/5/00
32	2.2.4 ติดตั้งโคมไฟ	2 days	Mon 5/6/00	Tue 6/6/00
33	2.3 ระบบปรับและระบายอากาศ	28 days	Tue 9/5/00	Mon 5/6/00
34	2.3.1 พับท่อลม	17 days	Tue 9/5/00	Thu 25/5/00
35	2.3.2 ประกอบและติดตั้ง	19 days	Thu 11/5/00	Mon 29/5/00
36	2.3.3 ติดตั้งหน้ากากลม	1 day	Mon 5/6/00	Mon 5/6/00
37	2.4 งานอุปกรณ์ครัว	5 days	Fri 19/5/00	Tue 23/5/00
38	2.4.1 ติดตั้ง HOOD	2 days	Mon 22/5/00	Tue 23/5/00
	2.4.2 ติดตั้งอุปกรณ์ครัว	5 days	Fri 19/5/00	Tue 23/5/00
40	2.5 ประปา (เดินท่อและติดตั้งเครื่องกรองน้ำ)	7 days	Mon 22/5/00	Sun 28/5/00
41	3. งานหลังเฮดเชียร์	30 days	Mon 15/5/00	Tue 13/6/00
42	3.1 งานตกแต่งภายใน	30 days	Mon 15/5/00	Tue 13/6/00
43	3.1.1 ก่ออิฐมอญและฉาบ	5 days	Mon 15/5/00	Fri 19/5/00
44	3.1.2 ปูกระเบื้องพื้นและผนัง	2 days	Sat 20/5/00	Sun 21/5/00
46	3.1.3 ปูหินอ่อนเคาน์เตอร์	1 day	Mon 29/5/00	Mon 29/5/00
46	3.1.4 BUILT-IN เฟอร์นิเจอร์	10 days	Wed 24/5/00	Fri 2/6/00
47	3.1.5 โครงฝ้า	1 day	Sat 10/6/00	Sat 10/6/00
48	3.1.6 ปิดแผ่นฝ้า	1 day	Sun 11/6/00	Sun 11/6/00
49	3.1.7 ฉาบทาสี	2 days	Mon 12/6/00	Tue 13/6/00
60	3.2 งานระบบไฟฟ้า	13 days	Thu 25/5/00	Mon 12/6/00
61	3.2.1 WIREWAY/CONDUIT	5 days	Thu 25/5/00	Mon 29/5/00
62	3.2.2 WIRING	6 days	Tue 30/5/00	Sat 3/6/00
63	3.2.3 SWITCH/OUTLET	4 days	Mon 5/6/00	Thu 8/6/00
64	3.2.4 ติดตั้งโคมไฟ	2 days	Sun 11/6/00	Mon 12/6/00
66	3.3 งานติดลมกหน้ากากลม	7 days	Tue 30/5/00	Mon 5/6/00
56	4. งานโน้มพื้นที่ระบบ	58 days	Sat 29/4/00	Sun 25/6/00

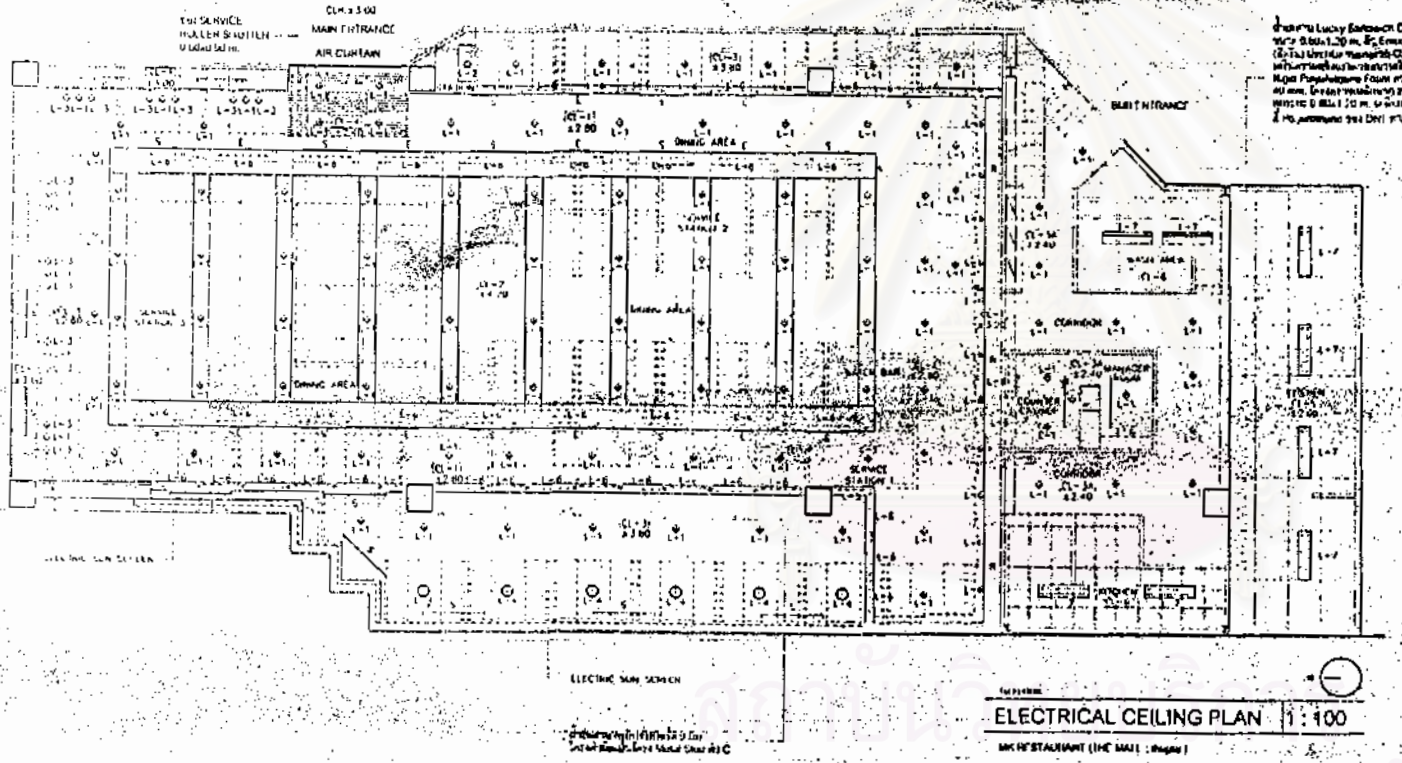
	4.1.1 งานรื้อผนังเดิม	10 days	Fri 5/5/00	Sun 14/5/00
	4.1.2 งานตกแต่งผนังเดิม	10 days	Mon 15/5/00	Wed 24/5/00
	4.1.3 เท Topping พื้น	2 days	Sun 7/5/00	Mon 8/5/00
61	4.1.4 ปูกระเบื้องพื้น	7 days	Tue 9/5/00	Mon 10/6/00
62	4.1.5 งานตกแต่งผนังทั่วไปภายในโรงงาน	45 days	Tue 9/5/00	Sun 25/6/00
63	4.1.6 งาน BUILT-IN เฟอร์นิเจอร์	40 days	Mon 15/5/00	Fri 23/6/00
64	4.1.7 งานติดตั้งประตูม้วน	2 days	Sat 17/6/00	Sun 18/6/00
65	4.1.8 งานติดตั้งกระจก	3 days	Tue 20/6/00	Thu 22/6/00
66	4.1.9 โครงฝ้า	7 days	Sun 11/6/00	Sat 17/6/00
67	4.1.10 ปิดแผ่นฝ้า	5 days	Thu 15/6/00	Mon 19/6/00
68	4.1.11 งานทาสี	10 days	Fri 16/6/00	Sun 25/6/00
69	4.2 งานระบบไฟฟ้า	52 days	Tue 2/5/00	Thu 22/6/00
70	4.2.1 CONDUITพื้น	3 days	Tue 2/5/00	Thu 4/5/00
71	4.2.2 CONDUITเพดาน	7 days	Sat 20/5/00	Fri 26/5/00
72	4.2.3 WIRING	5 days	Sat 27/5/00	Wed 31/5/00
73	4.2.4 FLEXIBLE CONDUIT	3 days	Thu 1/6/00	Sat 3/6/00
74	4.2.5 SWITCH/OUTLET	5 days	Fri 9/6/00	Tue 13/6/00
75	4.2.6 ติดตั้งโคมไฟ	5 days	Sun 18/6/00	Thu 22/6/00
76	4.2.7 ติดตั้งลำโพง	2 days	Wed 21/6/00	Thu 22/6/00
77	4.2.8 ติดตั้ง Heat Detector	2 days	Wed 21/6/00	Thu 22/6/00
	4.3 ประปา (เดินท่อและทดสอบท่อ)	3 days	Sun 21/5/00	Tue 23/5/00
79	4.4 ระบบปรับและระบายอากาศ	56 days	Sat 29/4/00	Fri 23/6/00
80	4.4.1 ส่งตัวอย่างท่อลม	5 days	Sat 29/4/00	Wed 3/5/00
81	4.4.2 พันท่อลม	30 days	Thu 4/5/00	Fri 2/6/00
82	4.4.3 ประกอบและติดตั้ง	30 days	Tue 9/5/00	Wed 7/6/00
83	4.4.4 ติดตั้งหน้ากากลม	3 days	Wed 21/6/00	Fri 23/6/00
84	4.4.5 ติดตั้งป่านอากาศ	1 day	Wed 21/6/00	Wed 21/6/00
85	4.5 ระบบท่อดับเพลิง			
86	4.5.1 ประกอบและเชื่อมท่อ			
87	4.5.2 ทดสอบแรงดันท่อ			
88	4.5.3 ทาสีท่อ			
89	4.5.4 ติดตั้งหัวดับเพลิง			
90	5. งานเฟอร์นิเจอร์ลอยตัว	57 days	Sat 29/4/00	Sat 24/6/00
91	5.1 งานตกแต่งภายใน	54 days	Sat 29/4/00	Wed 21/6/00
92	5.1.1 ส่งตัวอย่างไม้ และโซฟา	10 days	Sat 29/4/00	Mon 8/5/00
93	5.1.2 ประกอบที่โรงงาน	41 days	Tue 9/5/00	Sun 18/6/00
94	5.1.3 นำเข้าติดตั้งในหน่วยงาน	3 days	Mon 19/6/00	Wed 21/6/00
	5.2 เดินสายไฟฟ้าและอุปกรณ์	4 days	Wed 21/6/00	Sat 24/6/00
96	6. อุปกรณ์หลัก	49 days	Sat 29/4/00	Fri 16/6/00
97	6.1 แผงไฟฟ้า(DB,LOAD CENTER)	33 days	Sat 29/4/00	Wed 31/5/00
98	6.1.1 ขออนุมัติ	10 days	Sat 29/4/00	Mon 8/5/00
99	6.1.2 สั่งของ	20 days	Tue 9/5/00	Sun 28/5/00
100	6.1.3 ติดตั้ง	3 days	Mon 29/5/00	Wed 31/5/00
101	6.2 AHU	49 days	Sat 29/4/00	Fri 16/6/00
102	6.2.1 ขออนุมัติ	10 days	Sat 29/4/00	Mon 8/5/00
103	6.2.2 สั่งของ	30 days	Tue 9/5/00	Wed 7/6/00
104	6.2.3 ติดตั้ง	3 days	Thu 8/6/00	Sat 10/6/00
105	6.2.4 งานท่อน้ำเย็น	3 days	Sun 11/6/00	Tue 13/6/00
106	6.2.5 ติดตั้งอุปกรณ์	2 days	Thu 15/6/00	Fri 16/6/00
107	6.3 FAN	32 days	Sat 29/4/00	Tue 30/5/00
108	6.3.1 ขออนุมัติ	10 days	Sat 29/4/00	Mon 8/5/00
109	6.3.2 สั่งของ	20 days	Tue 9/5/00	Sun 28/5/00
[illegible]	[illegible]	2 days	Mon 29/5/00	Tue 30/5/00
111	6.4 STARTER & REMOTE PANEL	5 days	Fri 2/6/00	Tue 6/6/00
112	6.5 CONDUIT & WIRING	5 days	Wed 7/6/00	Sun 11/6/00



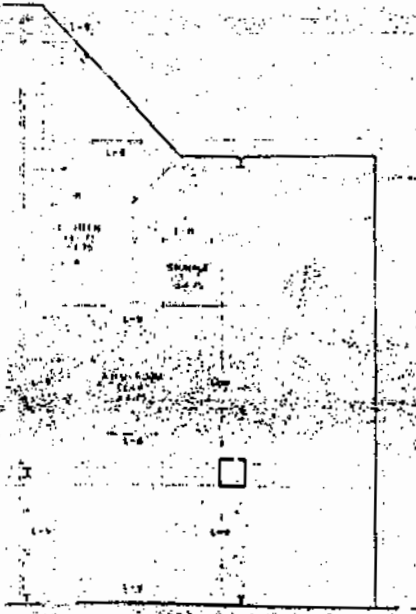
Project: [illegible] | Task | Progress | Milestone ◆ | Summary

		Duration	Start	Finish
	...งานโครงสร้างพื้นชั้นลอย	58 days	Wed 3/5/00	Thu 29/6/00
	7.1 งานติดตั้งโครงสร้างหลักและพื้นชั้นลอย	27 days	Wed 3/5/00	Mon 29/5/00
116	7.2 งานทับหน้าคอนกรีต	7 days	Wed 21/6/00	Tue 27/6/00
118	7.3 งานปูกระเบื้องยาง	2 days	Wed 23/6/00	Thu 29/6/00
117	7.4 งานเดินท่อ Conduit และติดตั้งไลน์ไฟ	4 days	Wed 21/6/00	Sat 24/6/00
118	8. ตรวจรับงาน	1 day	Wed 5/7/00	Wed 5/7/00
119	9. ติดตั้งงานป้าย และงานศิลปกรรม	4 days	Sat 8/7/00	Tue 11/7/00
120	10. งานเก็บ	7 days	Wed 5/7/00	Tue 11/7/00
121	11. COMMISSIONING & TEST RUN	10 days	Sun 2/7/00	Tue 11/7/00
122	12. ทำความสะอาด	7 days	Wed 5/7/00	Tue 11/7/00
123	13. ส่งมอบงาน	1 day	Tue 11/7/00	Tue 11/7/00
124	14. MK จัดเตรียมอุปกรณ์			
125	15. เปิดให้บริการ			

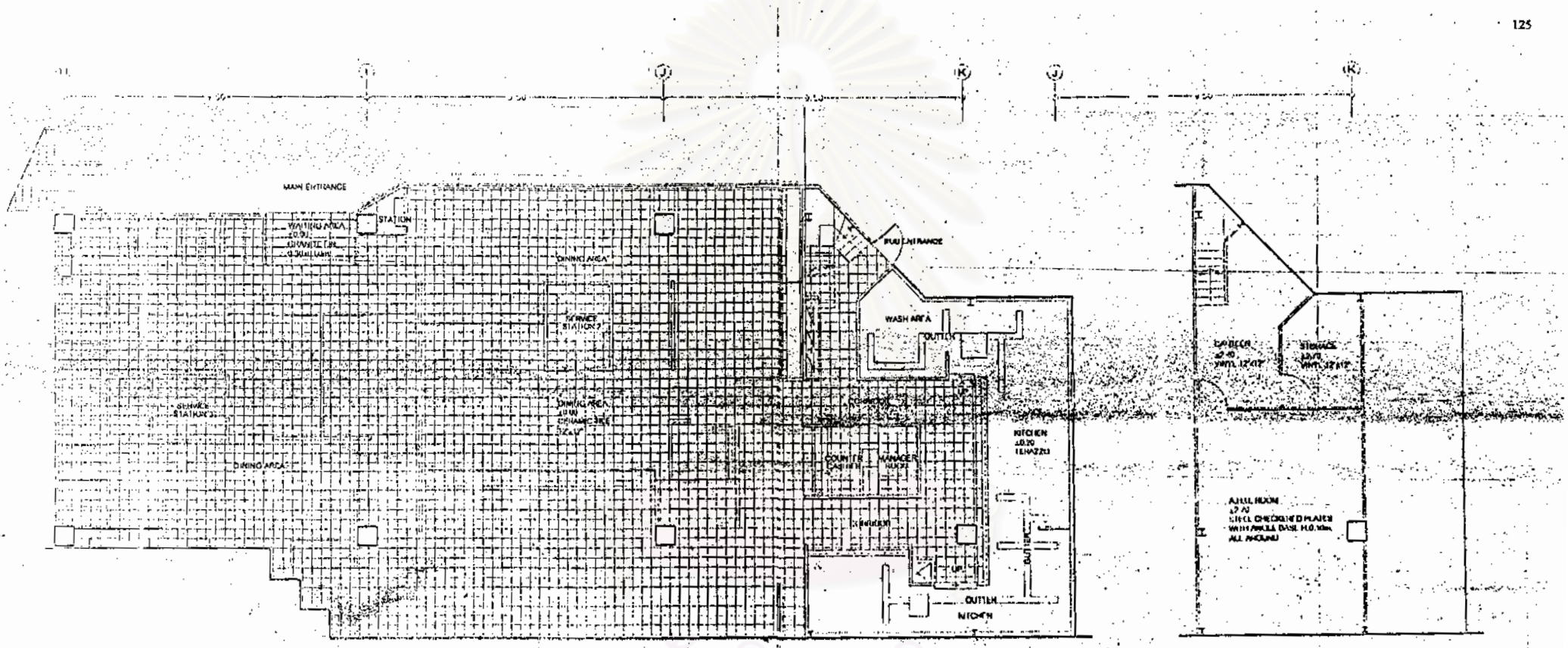
Appendix B



ELECTRICAL CEILING PLAN | 1 : 100



ELECTRICAL CEILING PLAN | 1 : 100



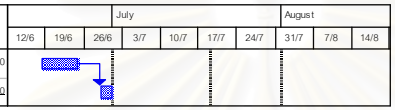
TREATMENT FLOOR PLAN | 1 : 100

TREATMENT FLOOR PLAN | 1 : 100

Appendix C

Material Check Sheet

ID	Task Name	Duration	Start	Finish
48	Prepare the panel of doors	7 days	Sun 18/6/00	Sat 24/6/00
49	Install doors and equipment	2 days	Thu 29/6/00	Fri 30/6/00



Project Mk The Mall Tha Pra

Project Code 2012

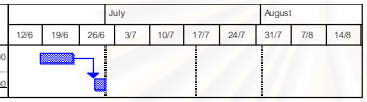
Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
D-3	ประตูโลหะ	ชุด	1.0	7,684.00	7,684.00	3		3	C
D-3	ม่านกันแมลง	ชุด	1	3,660.00	3,660.00	3		3	C
D-1	ประตูบาน ROLLER SHUTTER (STAINLESS)	ชุด	1	25,000.00	25,000.00				S
	ตอนล่างทึบสูงจากพื้น 0.60 เมตร								
	ตอนบนโปร่งลายอิฐตรง (Subcontract)								
					-				

May																												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June																												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
48	Prepare the panel of doors	7 days	Sun 18/6/00	Sat 24/6/00
49	Install doors and equipment	2 days	Thu 29/6/00	Fri 30/6/00



Project Mk The Mall Tha Pra

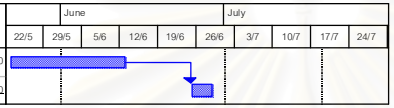
Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
D-2	ไม้สัก 2"X4"X 8.5'	ท่อน	2.0	803.00	1,606.00	3		3	C
D-2	ไม้สัก 2"X4"X 3.5'	ท่อน	1	252.00	252.00	3		3	C
D-2	ประตูไม้อัดสัก 6 mm.	แผ่น	2	450.00	900.00	3		3	C
D-2	ไม้จำปา 1"x2"x8.5'	ท่อน	8	88.00	704.00	3		3	C
D-2	มือจับ NO. 102-04-600	ตัว	2	233.00	466.00	3		3	C
D-2	950 SERIES NO. 950 W-1	ชุด	1	2,900.00	2,900.00	3		3	C
D-2	โช๊ก FC 2000-AL	ชุด	1	1,970.00	1,970.00	3		3	C
D-4	วงกบไม้ 100x200	ชุด	1	556.00	556.00	3		3	C
D-4	บานประตู 100x200	ชุด	1	400.00	400.00	3		3	C
D-4	ลูกบิด 630	ชุด	1	850.00	850.00	3		3	C
D-5	วงกบไม้ 80x200	ชุด	1	380.00	380.00	3		3	C
D-5	บานไม้อัด	ชุด	1	480.00	480.00	3		3	C
D-5	มือจับ	ตัว	2	246.00	492.00	3		3	C
D-5	กลอน	ชุด	1	170.00	170.00	3		3	C
D-2+4+5	บานพับ SW781 US 32D	ตัว	10	190.00	1,900.00	3		3	C

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
45	Assembly loose furnitures at the factory	21 days	Tue 23/5/00	Mon 12/6/00
46	Install loose furnitures	4 days	Sun 25/6/00	Wed 28/6/00



Project Mk The Mall Tha Pra

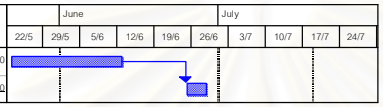
Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
	TOPหิน	ตารางเมตร	53.3	2,000.00	106,560.00	7		7	A
	ไม้โครง1.5*3*6'	ท่อน	260	53.00	13,780.00	3		3	B
	ไม้โครง1*2*2.5ม.	ท่อน	398	22.50	8,955.00	3		3	B
	ไม้โครง1.5"*3"*5'	ท่อน	288	44.00	12,672.00	3		3	B
	ไม้โครง1.5"*3"*4.5'	ท่อน	64	39.00	2,496.00	3		3	C
	ไม้โครง1.5"*3"*3'	ท่อน	16	26.00	416.00	3		3	C
	ไม้อัดยาง 10 มม. B.	แผ่น	73.5	275.00	20,212.50	3	2	5	B
	ไม้อัดยาง 6 มม. B.	แผ่น	20.5	180.00	3,690.00	3		3	C
	ไม้อัดยาง 4 มม. B.	แผ่น	98.78	140.00	13,829.20	3		3	C
	ไม้อัดลัก 4 มม.	แผ่น	12	340.00	4,080.00	3		3	C
	ไม้ลัก 1"X6"X 2'	ท่อน	4	108.00	432.00	3		3	C
	ไม้ลัก 1"X6"X 1.5'	ท่อน	2	181.00	362.00	3		3	C
	ไม้ลัก 1"X2"X 5'	ท่อน	220	59.00	12,980.00	3		3	C
	ไม้ลัก 1.5"X2"X 3'	ท่อน	48	45.00	2,160.00	3		3	C
	ไม้ลัก 1"X2"X 3'	ท่อน	184	35.00	6,440.00	3		3	C

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
45	Assembly loose furnitures at the factory	21 days	Tue 23/5/00	Mon 12/6/00
46	Install loose furnitures	4 days	Sun 25/6/00	Wed 28/6/00



Project Mk The Mall Tha Pra

Project Code 2012

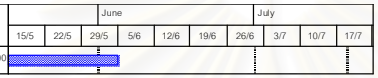
Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
	หนังเทียม	หลา	53.0	200.00	10,590.00	3		3	C
	เหล็กฉากเจาะรู	ท่อน	40	310.00	12,400.00	3		3	C
	อุปกรณ์ยึด	ชุด	40	10.00	400.00	3		3	C
	ไม้ปิดขอบโต๊ะ (ตามแบบ)	เมตร	225.1	20.00	4,502.00	3		3	C
	ขาสแตนเลส	ชุด	77		352,000.00	28			A
	กรอบสแตนเลสกระจก	ชุด	19		66,000.00	28			B

May																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
32	Prepare built-in furniture in the sale area	21 days	Mon 15/5/00	Sun 4/6/00



Project Mk The Mall Tha Pra

Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
B-10,11,14,14A	ไม้อัดยาง 10 mm.	แผ่น	19.0	275.00	5,225.00	3		3	B
B-10,11,14,14A	ไม้อัดยาง 6 mm.	แผ่น	4	180.00	720.00	3		3	C
B-10,11,14,14A	ไม้อัดยาง 4 mm.	แผ่น	5	140.00	700.00	3		3	C
B-10,11,14,14A	ไม้อัดลัก 4 mm.	แผ่น	4.5	340.00	1,530.00	3		3	C
B-10,11,14,14A	ไม้สัก 2"x2"x5'	ท่อน	8	174.00	1,392.00	3		3	C
B-10,11,14,14A	ไม้สัก 1"x2"x8'	ท่อน	21	178.00	3,738.00	3		3	C
B-10,11,14,14A	ไม้สัก 1"x2"x5'	ท่อน	6	59.00	354.00	3		3	C
B-10,11,14,14A	ไม้สัก 1"x2"x3'	ท่อน	24	35.00	840.00	3		3	C
B-10,11,14,14A	ไม้โครง 1.5"x3"x8'	ท่อน	23	70.00	1,610.00	3		3	C
B-10,11,14,14A	ไม้โครง 1"x2"x8'	ท่อน	33	22.50	742.50	3		3	C
B-10,11,14,14A	โฟเมก้า 4627-60	แผ่น	11	950.00	10,450.00	3		3	B
B-10,11,14,14A	หนังเทียม ZLTS1M-034	หลา	10.55	200.00	2,110.00	3		3	C

May

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

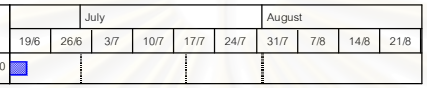
June

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
29	Install built-in furniture in the cashier area	3 days	Mon 19/6/00	Wed 21/6/00



Project Mk The Mall Tha Pra

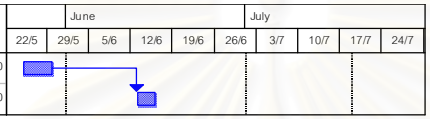
Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
B-17	หินแกรนิตดำในประเทศ 35x210	แผ่น	1	1,470.00	1,470.00	7		7	C
B-17	หินแกรนิตเขียวรัสเซีย 30x60	แผ่น	16	531.00	8,496.00	7		7	A
B-17+B-18	กระเบื้อง 4"x12"	แผ่น	15	16.00	240.00				C,S

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
26	Lay wall bricks, wash, and pave wall tiles in t	5 days	Thu 25/5/00	Mon 29/5/00
27	Pave ground tiles in the cashier area	3 days	Tue 13/6/00	Thu 15/6/00



Project: Mk The Mall Tha Pra

Project Code: 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
1.3	ผนังก่ออิฐมอญฉาบเรียบ	ตารางเมตร	24	520.00	12,480.00				A,S
1.3	กระเบื้อง RSM 011 GREEN ขนาด 4"x12" ของ RCI	ตารางเมตร	21	75.00	1,575.00				C,S
1.3+1.4	กระเบื้องสีขาวนางนวลขนาด 8"x8" ของ COTTO	ตารางเมตร	51	305.00	15,555.00				B,S
1.3	ไม้อัดยาง 10 mm.	แผ่น	11	275.00	3,025.00	3		3	B
1.3	แผ่น Laminate NO. 4627-60	แผ่น	11	945.00	10,395.00	3		3	C
1.3	เส้นแผ่น STANLESS 4"x3 mm.x2.40 m.	แผ่น	4	800.00	3,200.00				S
1.3+1.4	กระเบื้อง RSM 011 GREEN (ชนิดด้าน) ขนาด 12"x12"	ตารางเมตร	39.7	305.00	12,108.50				A,S
	ของ RCI								

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish	July						August			
					19/6	26/6	3/7	10/7	17/7	24/7	31/7	7/8	14/8	21/8
22	Install kitchen equipment	4 days	Thu 22/6/00	Sun 25/6/00										

Project Mk The Mall Tha Pra

Project Code 2012

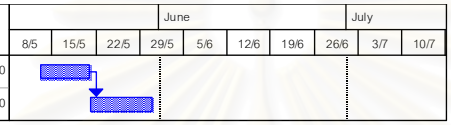
Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
B20+B21	เหล็กตัว T	ตัว	17	50.00	850.00	3		3	C
B20+B21	ไม้อัดยาง 15 mm.	แผ่น	4	500.00	2,000.00	3		3	C

May																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
7	Install mezzanine and stair main structure	8 days	Sat 13/5/00	Sat 20/5/00
8	Finish mezzanine structure	10 days	Sun 21/5/00	Tue 30/5/00



Project Mk The Mall Tha Pra

Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
7	โครงสร้างชั้นลอย	ชุด	1	206,871.00	206,871.00				A,S
7	โครงสร้างบันได	ชุด	1	18,778.00	18,778.00				C,S

May

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

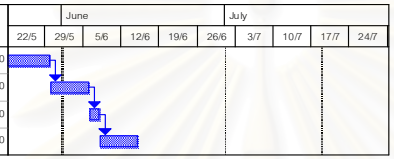
June

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
16	Lay wall bricks, and wash walls in the kitchen	8 days	Mon 22/5/00	Mon 29/5/00
17	Pave wall tiles in the kitchen area	7 days	Tue 30/5/00	Mon 5/6/00
18	Lay foam and place concrete	2 days	Tue 6/6/00	Wed 7/6/00
19	Place terrazzo and polish terrazzo	7 days	Thu 8/6/00	Wed 14/6/00



Project Mk The Mall Tha Pra

Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
1.5	ผนังก่ออิฐ และฉาบ	ตารางเมตร	95	520.00	49,400.00				A,S
1.5	ผนังปูกระเบื้องสีขาวนวล ขนาด 8"x8" ของ COTTO	ตารางเมตร	95	305.00	28,975.00				B,S
1.5	พื้นปรับระดับ+เท ค.ส.ล.	ตารางเมตร	53	600.00	31,800.00				B,S
1.5	โฟม หนา 10 cm. 0.30x0.60 m.	ตารางเมตร	53	60.00	3,180.00	3		3	C
1.5	พื้นหินขัดสีเทา	ตารางเมตร	53	380.00	20,140.00				C,S

May

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

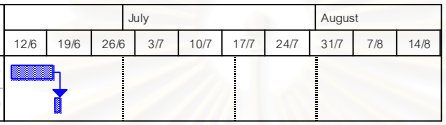
June

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
10	Install light partition, wash, and paint in the ma	7 days	Tue 13/6/00	Mon 19/6/00
11	Pave vinyl tiles at the mazzanine&stair area	1 day	Tue 20/6/00	Tue 20/6/00



Project Mk The Mall Tha Pra

Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
1.6+1.7	ผนัง METAL STUD กรุแผ่น 1 ด้าน	ตารางเมตร	19.9	300.00	5,970.00				C,S
1.6+1.7	ผนัง METAL STUD กรุแผ่น 2 ด้าน	ตารางเมตร	84	360.00	30,240.00				B,S
1.6+1.7	ผนังทาสีขาวน้ำมัน NO.272 ของ ICI	ตารางเมตร	144	80.00	11,520.00				C,S
1.6	กระเบื้องยาง	ตารางเมตร	22	190.00	4,180.00				C,S

May

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

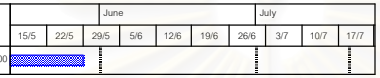
June

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
24	Prepare built-in furnitures in the cashier area	14 days	Mon 15/5/00	Sun 28/5/00



Project: Mk The Mall Tha Pra

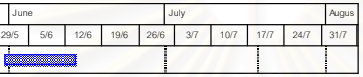
Project Code: 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
B-17,18,19	ไม้โครง 1"x2"x8'	มัด	10.0	225.00	2,250.00	3		3	B
B-17,18,19	ไม้อัดสัก 6 mm.	แผ่น	3	180.00	540.00	3		3	C
B-17,18,19	ไม้อัดสัก 4 mm.	แผ่น	17	340.00	5,780.00	3		3	C
B-17,18,19	ไม้อัดยาง 4 mm.	แผ่น	2	140.00	280.00	3		3	C
B-17,18,19	ไม้อัดยาง 15 mm.	แผ่น	0.5	500.00	250.00	3		3	C
B-17,18,19	ไม้สัก 1"x5"x3'	ท่อน	4	156.00	624.00	3		3	C
B-17,18,19	ไม้สัก 1"x4"x8'	ท่อน	3	356.00	1,068.00	3		3	C
B-17,18,19	ไม้สัก 1"x2"x8'	ท่อน	8	178.00	1,424.00	3		3	C
B-18	ไม้สัก 1"x5"x8'	ท่อน	2	150.00	300.00	3		3	C
B-17,18,19	ไม้สัก 1"x4"x4'	ท่อน	2	160.00	320.00	3		3	C
B-17,18,19	บานพับประตูพับขอบ	ตัว	6	20.00	120.00	3		3	C
B-17,18,19	มือจับ	ตัว	2	53.00	106.00	3		3	C
B-17,18,19	ไม้ก๊อบบอร์ด	แผ่น	6	110.00	660.00	3		3	C
B-17,18,19	รางลิ้นชัก 18"	ชุด	6	65.00	390.00	3		3	C
B-17,18,19	กุญแจล็อกหน้าลิ้นชัก	ชุด	3	95.00	285.00	3		3	C

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
40	Decorate general walls in the shop	14 days	Wed 31/5/00	Tue 13/6/00



Project Mk The Mall Tha Pra

Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
1.1.4	แผ่นยิบซั่มหนา 12 mm.	ตารางเมตร	1.0	64.00	64.00	3		3	C
1.1.5	แผ่นยิบซั่มหนา 12 mm. ขอบตรง	แผ่น	15	224.00	3,360.00	3		3	C
1.2.2	แผ่นยิบซั่มหนา 9 mm. ขอบลาด	แผ่น	6	184.00	1,104.00	3		3	C
1.1.6+B	ไม้อัดสัก 4 mm.	แผ่น	6	350.00	2,100.00	3		3	C
1.1.6	ไม้อัดยาง 6 mm. B.	แผ่น	4	180.00	720.00	3		3	C
1.1.6+1.2.1+B	ไม้อัดยาง 10 mm. B.	แผ่น	56.5	275.00	15,537.50	3		3	B
1.2.1	แผ่น PLASTWOOD หนา 5 mm.	แผ่น	12	1,190.00	14,280.00	3		3	C
1.1.6+1.2.1	แผ่น Laminate NO. 4627-60	แผ่น	12	945.00	11,340.00	3		3	C
B	โฟเมก้า NO. 4627-60	แผ่น	31.75	950.00	30,162.50	3	2	5	B
B	สแตนเลสตัว T ตามมุม	ชุด	1	45,000.00	45,000.00	28		28	B
B	เหล็กตัว T	ตัว	5	50.00	250.00	3		3	C
B	งานสแตนเลส	ชุด	17		227,500.00	28		28	A
1.1.3	เดือยเหล็ก Dia 1/2"	LS	1	500.00	500.00	3		3	C
B	ผนัง ค.ส.ล. ฉาบเรียบ	ตารางเมตร	67	520.00	34,840.00				B,S

May

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

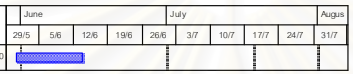
June

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
40	Decorate general walls in the shop	14 days	Wed 31/5/00	Tue 13/6/00



Project Mk The Mall Tha Pra

Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
1.1.1+B	หินแกรนิตเขียวรัสเซีย ขนาด 0.3x0.6 m.	แผ่น	262.1	531.00	139,181.00	7		7	A
B	หินแกรนิตดำในประเทศ 30x170 ซม.	แผ่น	1	1,122.00	1,122.00	7		7	C
1.1.2+1.2.3	กระเบื้อง RSM 011 GREEN ขนาด 12"x12" ของ RCI	ตารางเมตร	28.5	445.00	12,682.50				A,S
1.2.4	กระเบื้อง RSM 011 GREEN ขนาด 4"x12" ของ RCI	ตารางเมตร	98	75.00	7,350.00				C,S
B	กระเบื้อง-RSM 011 GREEN 4"x12"	แผ่น	239	16.25	3,883.75				C,S
B	กระเบื้อง-อิตาเลี่ยนขาว 8"x8"	แผ่น	938	22.19	20,814.22				B,S
B	ไม้โครง 1.5"x3"x2.5'	ท่อน	48	70.00	3,360.00	3		3	C
1.1.4,6+1.2.1,2+B	โครงไม้ 1"x2"x2.5 m.	ท่อน	263	22.50	5,917.50	3		3	B
1.1.8	ไม้เนื้อแข็ง PAPA 1"x4"x8'	ท่อน	5	167.00	835.00	3		3	C
1.1.3	ไม้ลัก 1.5"x1.5"x8'	ท่อน	54	200.00	10,800.00	3		3	C
1.1.3	ไม้ลัก 1.5"x4"x6'	ท่อน	2	362.00	724.00	3		3	C
1.1.6	ไม้ลัก 1.5"x1"x8'	ท่อน	2	121.00	242.00	3		3	C
B	ไม้ลัก 1"x2"x8'	ท่อน	4	178.00	712.00	3		3	C
1.1.5	ชุดโครงเหล็ก	ชุด	1	19,450.00	19,450.00	3	2	5	C

May																												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June																														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish	July						August		
					12/6	19/6	26/6	3/7	10/7	17/7	24/7	31/7	7/8	14/8
39	Install built-in furniture in the sale area	5 days	Tue 13/6/00	Sat 17/6/00										

Project: Mk The Mall Tha Pra

Project Code: 2012

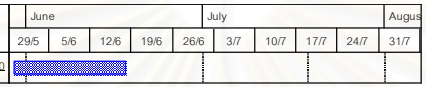
Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
B-10	หินแกรนิตรัสเซีย ขนาด 0.3x0.6 m.	แผ่น	20	531.00	10,620.00	7		7	A
B-10,11,14,14A	กระเบื้อง RSM 011 GREEN ขนาด 4"x12" ของ RCI	แผ่น	125	16.00	2,000.00				C,S
B-10,14,14A	ขาสแตนเลส	ขา	26	1,100.00	28,600.00	28		28	A
B-10,11	ชุดสแตนเลส	ชุด	2		52,000.00	28		28	A
B-11,14A	แผ่นสแตนเลส	เมตร	10	350.00	3,500.00	28		28	C
B-14,14A	สแตนเลสพิง Booth	ชุด	2	3,500.00	7,000.00	28		28	C
B-14	งานสแตนเลส BAR 2"	เมตร	2	350.00	700.00	28		28	C
B-14	งานเกลียวเหล็ก 1"x2"x2 m.	เส้น	3	280.00	840.00	3		3	C
B-10	ผนัง ค.ส.ล.	ตารางเมตร	10	520.00	5,200.00				B,S

May																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June																														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
37	Install ceiling in the sale area	19 days	Tue 30/5/00	Sat 17/6/00



Project Mk The Mall Tha Pra

Project Code 2012

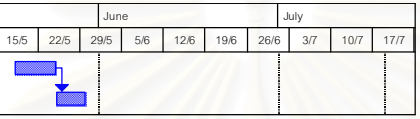
Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
CL-1+CL-2	ไม้โครง 1"x2"x2.5 m	มัด	100	225.00	22,500.00	3	2	5	B
CL-1+CL-2	แผ่นยิบซั่ม 9 mm.	แผ่น	102	184.00	18,768.00	3		3	C
CL-2	ไม้อัดยาง 10 mm.	แผ่น	55	275.00	15,125.00	3		3	B
CL-1	ไม้อัดยาง 4 mm.	แผ่น	10	140.00	1,400.00	3		3	C
CL-1	ไม้ PAPA 1"x4"x8'	ท่อน	4	167.00	668.00	3		3	C
CL-4	ไม้สัก 1.5"x1.5"x10'	ท่อน	22	584.00	12,848.00	3		3	C
CL-4	ไม้สัก 1.5"x1.5"x6'	ท่อน	3	145.00	435.00	3		3	C

May																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1

Notes:

Material Check Sheet

ID	Task Name	Duration	Start	Finish
35	Install partitions in the sale area	7 days	Thu 18/5/00	Wed 24/5/00
36	Place toping and pave ground tiles in the sal	5 days	Thu 25/5/00	Mon 29/5/00



Project Mk The Mall Tha Pra

Project Code 2012

Code	Material Description	Unit	Quantity	Unit Price	Total (Baht)	Lead Time	Safety Lead time	Total Lead Time	Control Level
1.1+1.2	ผนังก่ออิฐมอญฉาบเรียบ	ตารางเมตร	60	520.00	31,200.00				A,S
1.1	หินแกรนิตเขียวรัสเซีย ขนาด 0.30x0.60 m.	แผ่น	27.8	531.00	14,750.00	7		7	A
1.1	หินแกรนิตเขียวรัสเซีย ขนาด 0.10x0.30 m.	แผ่น	14	89.00	1,246.00	7		7	C
1.1	ขอบปูน	เมตร	3.2	150.00	480.00				C,S
1.2	กระเบื้อง RSM 011 Green ขนาด 12"x12" (ชนิดด้าน)	ตารางเมตร	295	500.00	147,500.00				A,S
	ของ ICI								

Notes:

Appendix D

The List of Materials used in the Case Study Project Sorted by the Value of each Material Item

ID	Material Item	Unit	Quantity	Unit Cost (Baht)	Total (Baht)	% of Total Costs	Cumulative Costs	% of Total Costs	Control Level
1	Stainless Legs	Pieces	77		380,600.00	18.05%	380,600.00	18.05%	A
2	Stainless Works	Pieces	20		324,500.00	15.39%	705,100.00	33.45%	A
3	Mezzanine Structure	Pieces	1	206,871.00	206,871.00	9.81%	911,971.00	43.26%	A
4	RSM 011 GREEN Tiles 12"x12" of RCI	Square meters	363.2	500.00	181,600.00	8.61%	1,093,571.00	51.87%	A
5	Green Russian Granite Sheet 0.30x0.60 m.	Pieces	326	531.00	173,106.00	8.21%	1,266,677.00	60.08%	A
6	Stone TOP	Square meters	53.28	2,000.00	106,560.00	5.05%	1,373,237.00	65.14%	A
7	Para Plywood 10 mm.	Pieces	215	320.00	68,800.00	3.26%	1,442,037.00	68.40%	B
8	Stainless Mirror Edge	Pieces	19		66,000.00	3.13%	1,508,037.00	71.53%	B
9	White-Cream Tiles 8"x8" of COTTO	Square meters	183.52	305.00	55,973.60	2.66%	1,564,010.60	74.19%	B
10	Frame wood 1"x2"x2.5 m	Pieces	1794	28.00	50,232.00	2.38%	1,614,242.60	76.57%	B
11	Formica NO. 4627-60	Pieces	42.75	950.00	40,612.50	1.93%	1,654,855.10	78.50%	B
12	Frame wood 1.5*3*6'	Pieces	260	140.00	36,400.00	1.73%	1,691,255.10	80.22%	B
13	Frame wood 1.5"*3"*5'	Pieces	288	120.00	34,560.00	1.64%	1,725,815.10	81.86%	B
14	METAL STUD lined Panel 2 side	Square meters	84	360.00	30,240.00	1.43%	1,756,055.10	83.30%	B
15	Teak wood 1"x2"x5'	Pieces	226	100.00	22,600.00	1.07%	1,778,655.10	84.37%	C
16	Laminate Sheets NO. 4627-60	Pieces	23	945.00	21,735.00	1.03%	1,800,390.10	85.40%	C
17	Para Plywood 4 mm.	Pieces	116.28	185.00	21,511.80	1.02%	1,821,901.90	86.42%	C
18	Gray Terrazzo	Square meters	53	380.00	20,140.00	0.96%	1,842,041.90	87.38%	C
19	Gypsum Board 9 mm.	Pieces	108	184.00	19,872.00	0.94%	1,861,913.90	88.32%	C
20	Iron Frame	Pieces	1	19,450.00	19,450.00	0.92%	1,881,363.90	89.24%	C
21	Stair Structure	Pieces	1	18,778.00	18,778.00	0.89%	1,900,141.90	90.13%	C
22	PLASTWOOD Sheets 5 mm.	Pieces	12	1,190.00	14,280.00	0.68%	1,914,421.90	90.81%	C
23	Teak Plywood 4 mm.	Pieces	39.5	350.00	13,825.00	0.66%	1,928,246.90	91.47%	C
24	Teak wood 1.5"x1.5"x10'	Pieces	22	584.00	12,848.00	0.61%	1,941,094.90	92.08%	C
25	Triangle Drilled Iron Works	Pieces	40	310.00	12,400.00	0.59%	1,953,494.90	92.66%	C
26	Substitute Leather ZLTS1M-034	Yards	63.5	190.00	12,065.00	0.57%	1,965,559.90	93.24%	C
27	White Oil Paint NO.272 of ICI	Square meters	144	80.00	11,520.00	0.55%	1,977,079.90	93.78%	C
28	Teak wood 1.5"x1.5"x8'	Pieces	54	200.00	10,800.00	0.51%	1,987,879.90	94.30%	C
29	Teak wood 1"x2"x3'	Pieces	208	50.00	10,400.00	0.49%	1,998,279.90	94.79%	C
30	RSM 011 GREEN Tiles 4"x12" of RCI	Square meters	134.42	75.00	10,081.50	0.48%	2,008,361.40	95.27%	C
31	Para Plywood 6 mm.	Pieces	28.5	270.00	7,695.00	0.37%	2,016,056.40	95.63%	C
32	Stainless Sheets	Meters	20	350.00	7,000.00	0.33%	2,023,056.40	95.96%	C
33	Stainless Booth	Pieces	2	3,500.00	7,000.00	0.33%	2,030,056.40	96.30%	C
34	Frame wood 1.5"*3"*4.5'	Pieces	64	105.00	6,720.00	0.32%	2,036,776.40	96.61%	C
35	METAL STUD lined Panel 1 side	Square meters	19.9	300.00	5,970.00	0.28%	2,042,746.40	96.90%	C
36	Teak wood 1"x2"x8'	Pieces	33	178.00	5,874.00	0.28%	2,048,620.40	97.18%	C
37	Table edge wood (According to the design)	Meters	225.1	20.00	4,502.00	0.21%	2,053,122.40	97.39%	C
38	Vinyl Tiles	Square meters	22	190.00	4,180.00	0.20%	2,057,302.40	97.59%	C
39	Frame wood 1.5"x3"x8'	Pieces	23	160.00	3,680.00	0.17%	2,060,982.40	97.76%	C
40	Gypsum Board 12 mm. Straight Edge	Pieces	15	224.00	3,360.00	0.16%	2,064,342.40	97.92%	C

The List of Materials used in the Case Study Project Sorted by the Value of each Material Item (Continued)

ID	Material Item	Unit	Quantity	Unit Cost (Baht)	Total (Baht)	% of Total Costs	Cumulative Costs	% of Total Costs	Control Level
41	Frame wood 1.5"x3"x2.5'	Pieces	48	70.00	3,360.00	0.16%	2,067,702.40	98.08%	C
42	STANLESS 4"x3 mm.x2.40 m.	Pieces	4	800.00	3,200.00	0.15%	2,070,902.40	98.23%	C
43	Foam Sheets10 cm. 0.30x0.60 m.	Square meters	53	60.00	3,180.00	0.15%	2,074,082.40	98.38%	C
44	950 SERIES NO. 950 W-1	Pieces	1	2,900.00	2,900.00	0.14%	2,076,982.40	98.52%	C
45	Teak wood 1.5"X2"X 3'	Pieces	48	60.00	2,880.00	0.14%	2,079,862.40	98.66%	C
46	Para Plywood 15 mm.	Pieces	4.5	500.00	2,250.00	0.11%	2,082,112.40	98.77%	C
47	Shoke FC 2000-AL	Pieces	1	1,970.00	1,970.00	0.09%	2,084,082.40	98.86%	C
48	Teak wood 2"x2"x5'	Pieces	8	200.00	1,600.00	0.08%	2,085,682.40	98.93%	C
49	Teak wood 2"X4"X 8.5'	Pieces	2	780.00	1,560.00	0.07%	2,087,242.40	99.01%	C
50	Domestic Dark Granite Sheets35x210 cm.	Pieces	1	1,470.00	1,470.00	0.07%	2,088,712.40	99.08%	C
51	Green Russian Granite Sheet 0.10x0.30 m.	Pieces	14	89.00	1,246.00	0.06%	2,089,958.40	99.14%	C
52	Teak Plywood 6 mm.	Pieces	3	400.00	1,200.00	0.06%	2,091,158.40	99.19%	C
53	Hinges	Pieces	6	190.00	1,140.00	0.05%	2,092,298.40	99.25%	C
54	Domestic Dark Granite Sheets30x170 cm.	Pieces	1	1,122.00	1,122.00	0.05%	2,093,420.40	99.30%	C
55	Frame wood 1.5"*3"*3'	Pieces	16	70.00	1,120.00	0.05%	2,094,540.40	99.35%	C
56	T Iron Works	Pieces	22	50.00	1,100.00	0.05%	2,095,640.40	99.41%	C
57	Handles	Pieces	4	246.00	984.00	0.05%	2,096,624.40	99.45%	C
58	Teak wood 1"x4"x8'	Pieces	3	300.00	900.00	0.04%	2,097,524.40	99.50%	C
59	Teak Plywood Door Panel 6 mm.	Pieces	2	450.00	900.00	0.04%	2,098,424.40	99.54%	C
60	Iron Strand Works 1"x2"x2 m.	Pieces	3	280.00	840.00	0.04%	2,099,264.40	99.58%	C
61	PAPA wood 1"x4"x8'	Pieces	5	167.00	835.00	0.04%	2,100,099.40	99.62%	C
62	Champac wood 1"x2"x8.5'	Pieces	8	95.00	760.00	0.04%	2,100,859.40	99.65%	C
63	Teak wood 1.5"x4"x6'	Pieces	2	362.00	724.00	0.03%	2,101,583.40	99.69%	C
64	Stainless Works BAR 2"	Meters	2	350.00	700.00	0.03%	2,102,283.40	99.72%	C
65	PAPA Wood 1"x4"x8'	Pieces	4	167.00	668.00	0.03%	2,102,951.40	99.75%	C
66	Goabboard	Pieces	6	110.00	660.00	0.03%	2,103,611.40	99.78%	C
67	Teak wood 1"x5"x3'	Pieces	4	150.00	600.00	0.03%	2,104,211.40	99.81%	C
68	Iron Spindle Dia 1/2"	Pieces	1	500.00	500.00	0.02%	2,104,711.40	99.84%	C
69	Teak wood 1"X6"X 2'	Pieces	4	120.00	480.00	0.02%	2,105,191.40	99.86%	C
70	Teak wood 1.5"x1.5"x6'	Pieces	3	145.00	435.00	0.02%	2,105,626.40	99.88%	C
71	Connecting Equipment	Pieces	40	10.00	400.00	0.02%	2,106,026.40	99.90%	C
72	Chest Rails 18"	Pieces	6	65.00	390.00	0.02%	2,106,416.40	99.92%	C
73	Teak wood 2"X4"X 3.5'	Pieces	1	320.00	320.00	0.02%	2,106,736.40	99.93%	C
74	Teak wood 1"x4"x4'	Pieces	2	160.00	320.00	0.02%	2,107,056.40	99.95%	C
75	Teak wood 2"x5"x2.5'	Pieces	2	150.00	300.00	0.01%	2,107,356.40	99.96%	C
76	Chest Locks	Pieces	3	95.00	285.00	0.01%	2,107,641.40	99.98%	C
77	Teak wood 1.5"x1"x8'	Pieces	2	121.00	242.00	0.01%	2,107,883.40	99.99%	C
78	Teak wood 1"X6"X 1.5'	Pieces	2	100.00	200.00	0.01%	2,108,083.40	100.00%	C
79	Gypsum Board 12 mm.	Square meters	1	64.00	64.00	0.00%	2,108,147.40	100.00%	C

Biography

Satit Tantivattanasatien was born on March 17,1978 in Bangkok, Thailand. He obtained Bachelor Degree in Industrial Engineering from Chulalongkorn University in 1998. In 1998 he enrolled as a full-time student of the regional center for manufacturing system engineering in engineering management.