Chapter 4

DATA ANALYSIS

4.1 THE EXISTING WORKING SYSTEM

A Engineering Consultants Co., Ltd. (A) is one of B group which has been established for 30 years. The system and work procedure of the company have been being slowly developed. Many years ago, these system and work procedure were still suitable. However, environment and market have been changed a lot in 3-4 years. The international clients and competitors come to do their business in Thailand. A has to adjust itself in order to achieve in high competitive market. The work procedure to design and supervise the construction project should be developed. At first, the existing design and supervision system has to be discussed in order to identify the problems of this system.

4.1.1 DESIGN WORK

After the customer awarded contract to A, the meeting between the clients and A was held. In this meeting, the clients provided more explanations of his factory and gives some necessary information to A. The engineers and architects of A offered the proposed structural design, materials and rough design concepts to the clients. After the conclusion from the meeting, A had to set a design team to accomplish this work.

4.1.1.1 Team Organization

At first, the project manager was selected. Usually, this person was a senior structural engineer. Then, he selected the people from other departments such as architects, civil engineers, electrical engineers, mechanical engineers, sanitary engineers to join his team. The responsibilities for each position in design team were as follow :

A Project Manager (PM)

(a) Administrative

P.M. took a responsibility as a decision making person of the project on the behalf of the company. He managed persons, time and money of his project. At the beginning of the project, he prepared the Project Organization Chart, arranged and conducted the kick - off meeting.

(b) External Coordination

P.M. coordinated with the client, obtain necessary information from him, and distributed to the concerned designers. Moreover, he obtained the work schedules from each departments and prepared the work schedules for the project. He also revised these schedules when necessary.

(c) Internal Coordination

P.M. coordinated the technical works of all departments in the design work. He helped the designers to obtain the technical information from other departments. After the design work was finished, he collected and arranged all drawings.

(d) Progress of Work

P.M. arranged a progress meeting as necessary. He prepared the Progress Reports and issued to the client. In order to control the time, he checked that the design works were proceeding according to the work schedule. If there were any problems arising during the progress of the design work, he arranged to solve these problems. Moreover, he prepared the list of drawings for the project and managed all the changed orders and additional works.

B Chief Designers

They took full responsibilities of the design works in their own groups. They assigned responsibilities to one or more junior designers in their groups. They supervised the works of their groups and performed some parts of these works if necessary. They obtained information from the project manager and distributed to the concerned designers. They also maintained work schedule and prepared reports as required by P.M. After the drawings were finished, they checked them before sending to the project manager.

C Junior Designers

They performed the design work as per requirements of the project and guidance of their chief designers. After designing, they assigned their works to the CAD operators to produce the drawings. They collected and checked their drawings before sending to chief engineers. They also provided some documents to their chiefs in order to prepare the report as required by P.M.

D CAD Operators

They took responsibilities to produce all of drawings

E Secretaries

They took responsibilities for the secretarial works of the projects.

F Other Staff

They took responsibilities as assigned by the project manager.

4.1.1.2 Design Process

After the design team had been established, the project manager distributed the information for each group to the senior designers. Each senior designer studies the scope of work and information from the clients. After that, he allocates the works for each designer and sets the work schedule for his own group. The meeting inside the group must be held. In

this meeting, the allocated work and work schedule were distributed to all junior designers. Normally, the works were separated depending on the characteristics of the work. For example, the structural works were seperated into concrete works and steel works. Each work was done by individual engineer. Then, each designer performed their assigned works. For engineers, they had to make the calculation sheets besides the drawings.

The CAD operators were the supported team for junior designers in order to produce the drawings. The junior designers sent their roughly hand sketched drawings to them. By these drawings, the CAD operators produced the complete ones with electronic files by the computers. The junior designers checked these drawings before sending them to their chief. These first issued drawings were called "Preliminary drawings".

The chief engineers checked these drawings before sending them to the project manager. This checking process took 2-3 days depended on the size of the project. The chief engineer investigated the concept of design, materials and size of member whether they were suitable and according to the customer's requirement. They did not check these drawings thoroughly because it was preliminary design-process. If some mistakes were found, those drawings were re-work again by the junior designers.

The project manager collects all of drawings from every groups. He had to prepare the list of drawings before sending all of them to the clients. It took about one or two weeks for the client to study the preliminary drawings. If there are not any comments, these drawings were approved and the detailed design was started.

Before the beginning of the detailed design, the project manager held a meeting between the client and A. The client provided A more information such as the characteristic of machine, positions and detailed of crane girder, etc. The project manager distributes this information to all concerned groups.

The design process in detailed design was the same as process in preliminary design but it took more time. The designers used their preliminary drawings to design more details such as the connection joints, the column base plate, etc. During the design process, the project manager checked the progress of work and coordinated both external and internal

company. He arranged to solve any problems between the client and company or between each group. Somethimes, he had to manage problems in design groups too. The chief designers maintained work schedule of their groups and provided necessary information to the junior designers.

During design process, if junior designers had any problems such as not enough data, they asked their chief or the project manager to help them. There were not certain procedure to specify whom they should contact with. Not only the problems solving, but also the change management which had not certain procedure. The project manager might give the changing data to chief designer or junior designer directly.

After the junior designers collected and checked all of drawings which were sent from the CAD operators, they sent all drawings to their chief designers for checking. The checking procedures for each chief designers were different although they were in the same group. They were depended on the experiences of each persons. The company did not develop the formal quality system. Sometimes, some items were not checked. No one could investigate this checking procedure after it had been passed because there were not any documents. Moreover, most of chief designers checked only the technical items such as size of the members, model of structures etc. They pay a little attention on the quality items such as size of letters, scale, etc.

Not only the checking procedures which were different groups by groups but also the drawings and calculation sheets. Each designer had his own style to demonstrate his design in terms of drawings. The calculation sheets from each engineer were not in the same format. The company did not develop the standard for the drawings, calculation sheet and CAD operation.

It took 3-4 days for chief designers to check the detail design drawings. If there were any errors, these drawings were re-worked before sending to the project manager.

The Project manager collected all drawings and made copies as identified in the contract. After checking the list of drawings and preparing the transmital form, all of these drawings were issued to the client. These drawings are called "For Construction Drawings"

The client took about 2 weeks to study these drawings and gave some comments. If there were not any comments, these drawings were used to prepare bidding documents. Then, A must help its client to select the contractor. After contractor selection, A allocated people to perform the supervising work in the site.

The organization chart of design team and design work procedure are shown as follow:

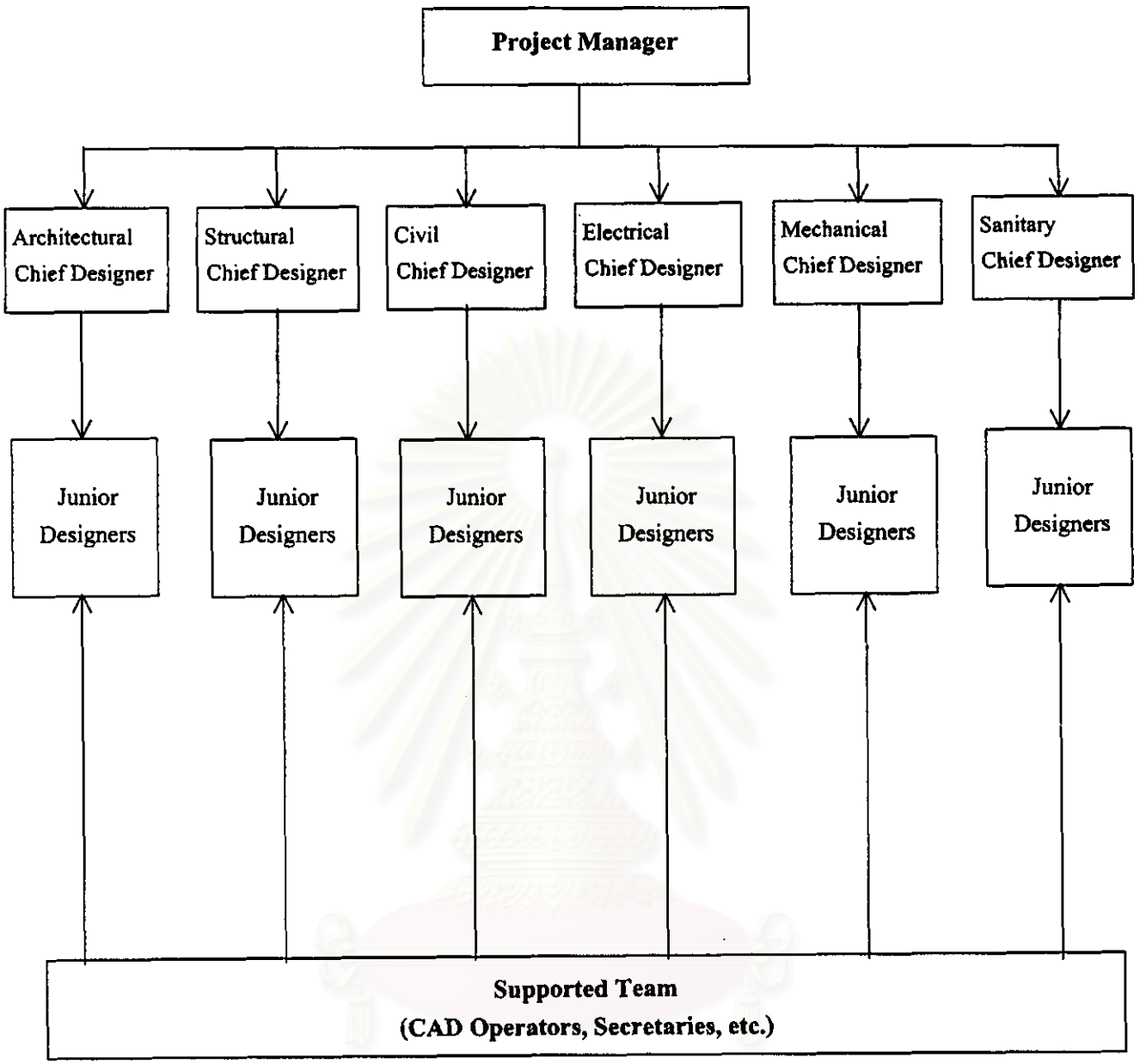


Figure 4.1 Design Team Organization Chart

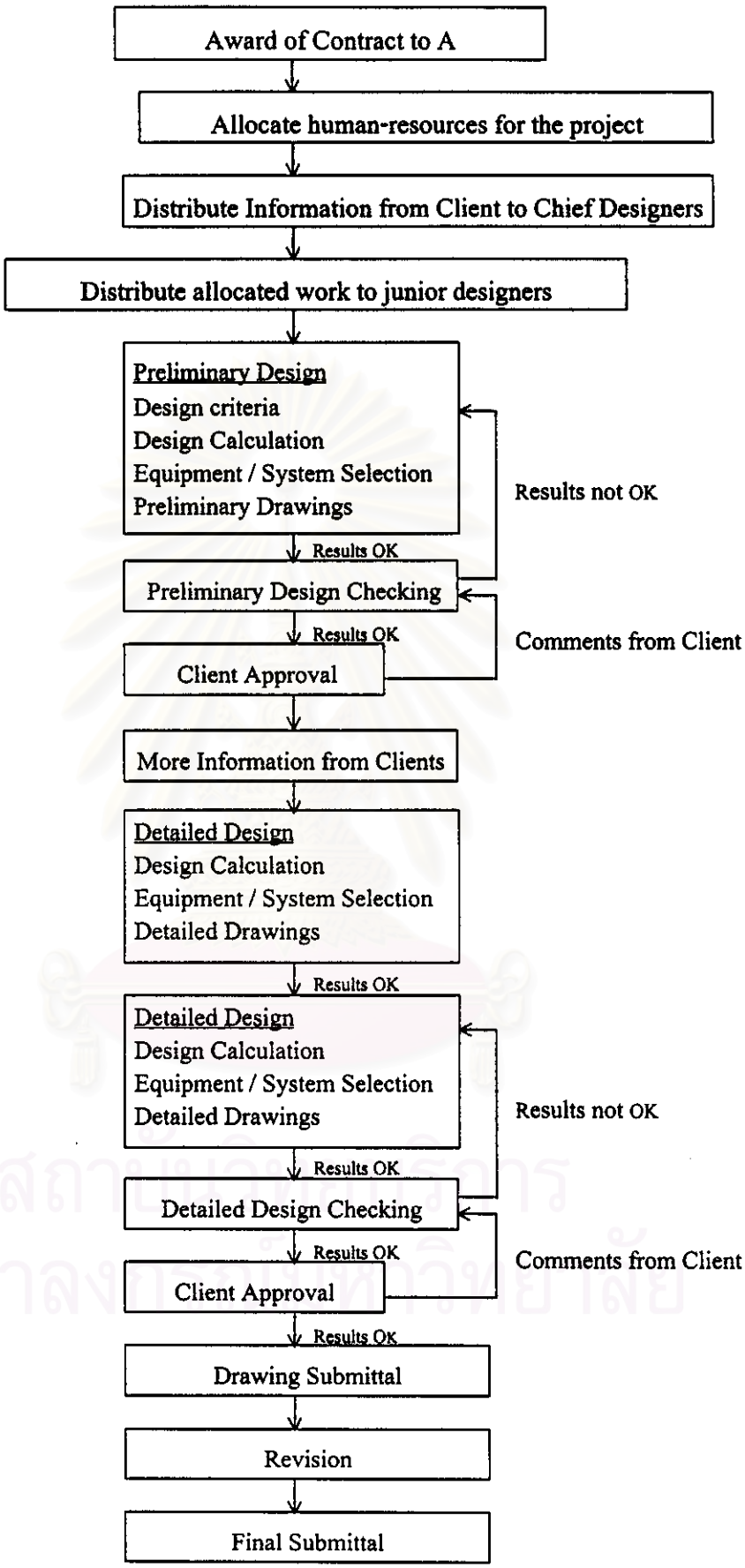


Figure 4.2 Design Procedure in Each Department

4.1.2 SUPERVISING WORK

The project manager selected the people from each department to work in construction site. Normally, these people were not the designers who performed the design work in this project. They were selected from other construction sites which were finished or nearly finished. They had a lot of supervising experiences. Their positions were "site engineers."

Besides site engineers, the project manager selected one person to work as "site manager". Usually, this person was a senior engineer with high experience in construction field. His work was to manage the resources and maintained the work schedule.

The inspectors were the support team for site engineers. They inspected the work of contractors and reported the progress of work to site engineers.

For the designers, after the detailed design process was finished, they were transfered to other projects. However, there were one or two key junior designers who visited the construction site with the project manager if there were some problems about the drawings. When these problems were occurred, the site manager were reported them to the project manager. Then, the project manager asked these key designers to solve these problems. If they cannot explained the solution by fax machine or telephone, they had to visit the construction site to solve the problems.

During the construction phase, the drawings might be revised many times. There were many reasons for these revisions such as the owner changed the type of machine in factory, the owner changed some parts of the factory to save money, the contractor could not work as shown in drawings and offerred other structure for approval. The project manager collected this information and distributed it to the chief designers. After the designers revised the drawings, the chief designers checked and sent them to the project manager to issue them to construction site.

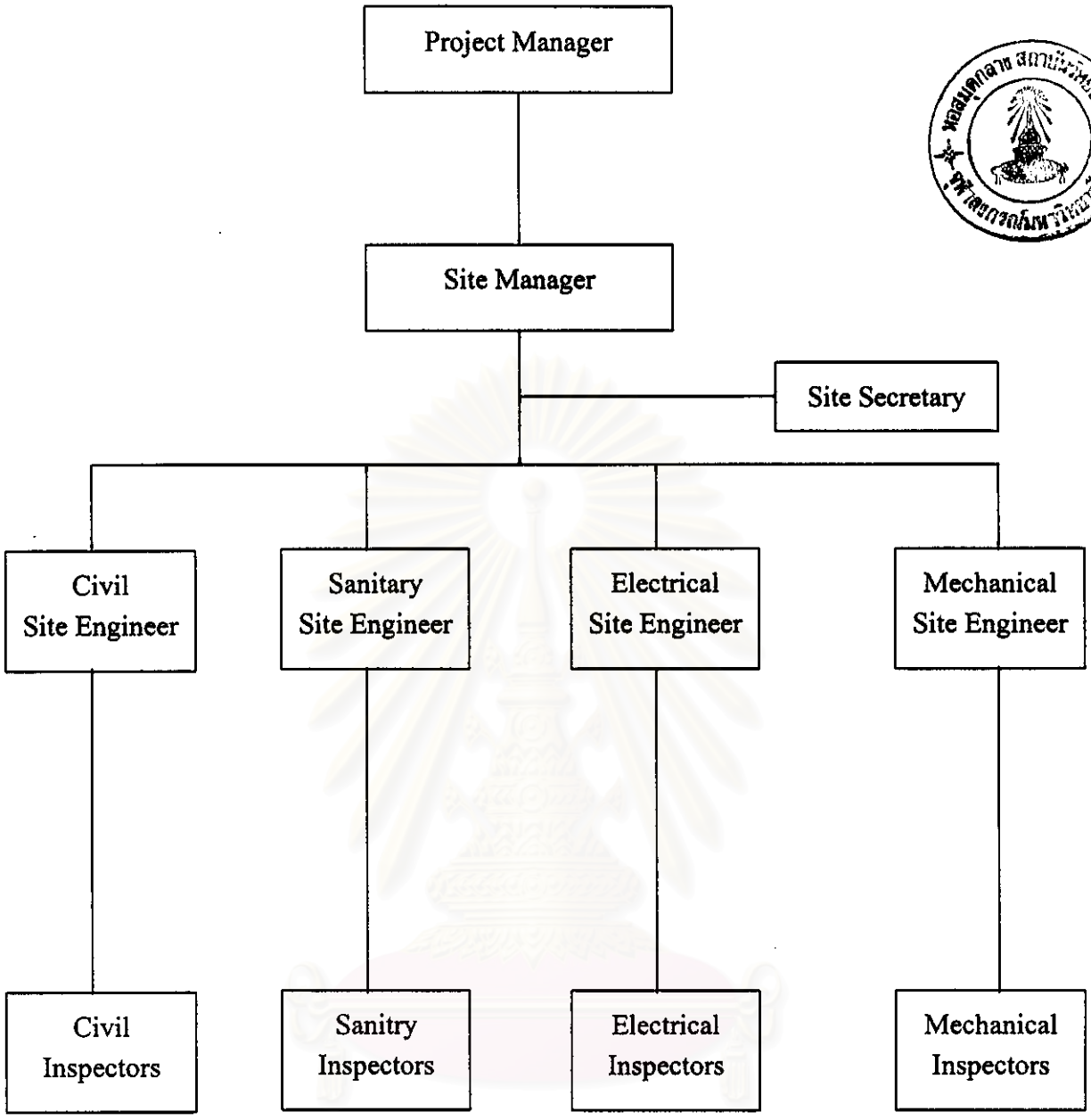


Figure 4.3 Organization Chart for Construction Supervision Work

From the existing system of A, some procedures take a long time. The project is not completed in time and the cost is more than estimated. The customers always claim for the quality of work. The problems and disadvantages from the existing system must be discussed in order to develop the system.

In this paper, the C Float Glass Project is used as case study to illustrate the cost and disadvantages of the existing working system. After new working system and method for calculating the cost of design and supervision are developed, this project will be used as an example to calculate the design and supervision cost based on the developed system.

4.2 BACKGROUND OF CASE STUDY

C Float Glass Co., Ltd. was in the process of expanding the magnitude of its float glass production by establishing a new glass manufacturing facility in Rayong, Thailand. The new C II Glass Factory with a production capacity of 600-650 tons per day had been started the design work in October, 1995. The construction work had been begun in Febuary, 1996. The project had been completed in September, 1997. A Engineering Consultant Co., Ltd. took a great opportunity to be the consultant for this project.

4.2.1 FEATURES OF THE PROJECT

Main features of the project are as follows:

4.2.1.1 General

The plant consists of two groups of buildings.

Group I Factory and process areas including utlity buildings, warehouse, and the main building.

Group II Batch house structure, Canteen and Structure.

The service for civil and structural works covers only the elements of the buildings of Group I, which include foundation, equipment pits, tunnels, superstructures, walls, roofing, siding and louvers.

The service for mechanical works covers air conditioning system, spot cooling, ventilation, fire prevention system, plumbing and sanitary system.

The service for electrical works covers the preperation of load schedule, lighting, outlet power, cable rooting, outlet telephone. The work also include the design of distribution board, panel board, fire alarm, lighting system, protection single line diagram H.V., diesel generator set.

4.2.1.3 Site Development

Include grading, earth works, drainage system, roads, parking lots, fences and gates.

4.2.1.4 Process Area

Include the furnace, tin bath, annealing line, cutting line, capping and unloading stations.

4.2.1.5 Utilities

Include substation, standby generator, lighting, domestic and industrial water supply, compressed air, ventilation, air conditioning, industrial drainage sanitary drainage, strom drainage, fire protection and motor control centers.

4.2.1.6 Warehouses

Include cullet material storage, tin storage, fuel (natural gas or oil), gases (Nitrogen, hydrogen) and product warehouse.

4.2.1.7 Main building

Include administrative and production offices, laboratory, weighing bridge, guard room.

4.2.1.8 Canteen

4.2.2 SCOPE OF ENGINEERING SERVICES

4.2.2.1 Design Work

a) Study the production process, the subsoil investigation and the site data provided by the owner.

b) Establish the design criteria, systems description and the reference standards to be applied in this Project.

c) Perform the necessary engineering and architectural designs.

d) Prepare all the necessary drawings and specifications for civil architectural, structural, mechanical and electrical works for all features as listed in Section 4.2.1

e) Prepare the bill of quantities and budget cost estimates of the project.

4.2.2.2 Construction Supervision and Management Works

The activities in this phase of services include the construction supervision of the civil works and interfaces and assist the Owner's specialists in the installation of the equipment and starting up of the plant. The order of activities are.

a) Prepare the Organization Chart with interrelation with the contractor, the Consultant and the Owner.

b) Approve the construction schedule prepared by the contractor.

c) Verify the shop-drawings submitted by the Contractor and approve in compliance with the design.

d) Monitoring the construction in compliance with the designs, specifications both in quality and quantity.

e) Monitoring the works in pace with the proposed schedule.

f) Verify the measure and payment and certify the invoices submitted by the Contractor in accordance to the Contract conditions.

g) Compile the as-built drawings, the operation and maintenance manuals submitted by the contractor and the suppliers.

h) Monitoring all agreements in compliance with the contractual conditions.

i) Advise in technical aspects relating to the Project.

j) Arrange regular meeting for all concerned parties to follow up the progress of the Project, to solve any encountering problem and to certify the work schedule.

k) Prepare monthly progress report covering all the on going activities and submit to the Owner.

l) Assist the Owner in Final Acceptance of the works.

4.2.2.3 Documents to be submitted

a) Engineering & Architectural drawings.

b) Specification.

c) Bill of quantities and cost estimates.

d) Contract documents.

e) Calculation Sheets.

f) Monthly progress reports.

4.2.2.4 Language and Units

All documents are prepared in English. All engineering units are in metric SI system.

4.2.2.5 Liaison with Authorities

The consultant will coordinate as liaison of the Owner to the concerned authorities in the matters related to the Project, such as construction permit, application for electrical supply, water supply.

4.2.3 ADAPTATION TO LOCALITY

Features of the Project are properly adapted to local conditions, i.e. climatology, subsoil condition, land cost, availability of construction materials, skill labors and equipment.

The Consultant pays attention to compare some particular features of the similar plants already exist in Thailand to the introduced model for their justifications. The observed features to be commented are:

- the on ground furnace versus the below ground furnace pit.
- the unloading station above storage versus same level arrangement.

4.2.4 CONTINUOUS OPERATION

The Consultant is informed that the plant is operating continuously for 7-8 years nonstop. By this constraint, the plant requires stand by power supply, water supply, reserved fuel, gases, raw materials, spare parts. Some features of the building has to endure high temperature for very long period.

4.2.5 RIGID TIME FRAME

The Owner had set the target date for the commencement of the construction by October, 1995. The total period of design and construction was limited to be within twenty one months.

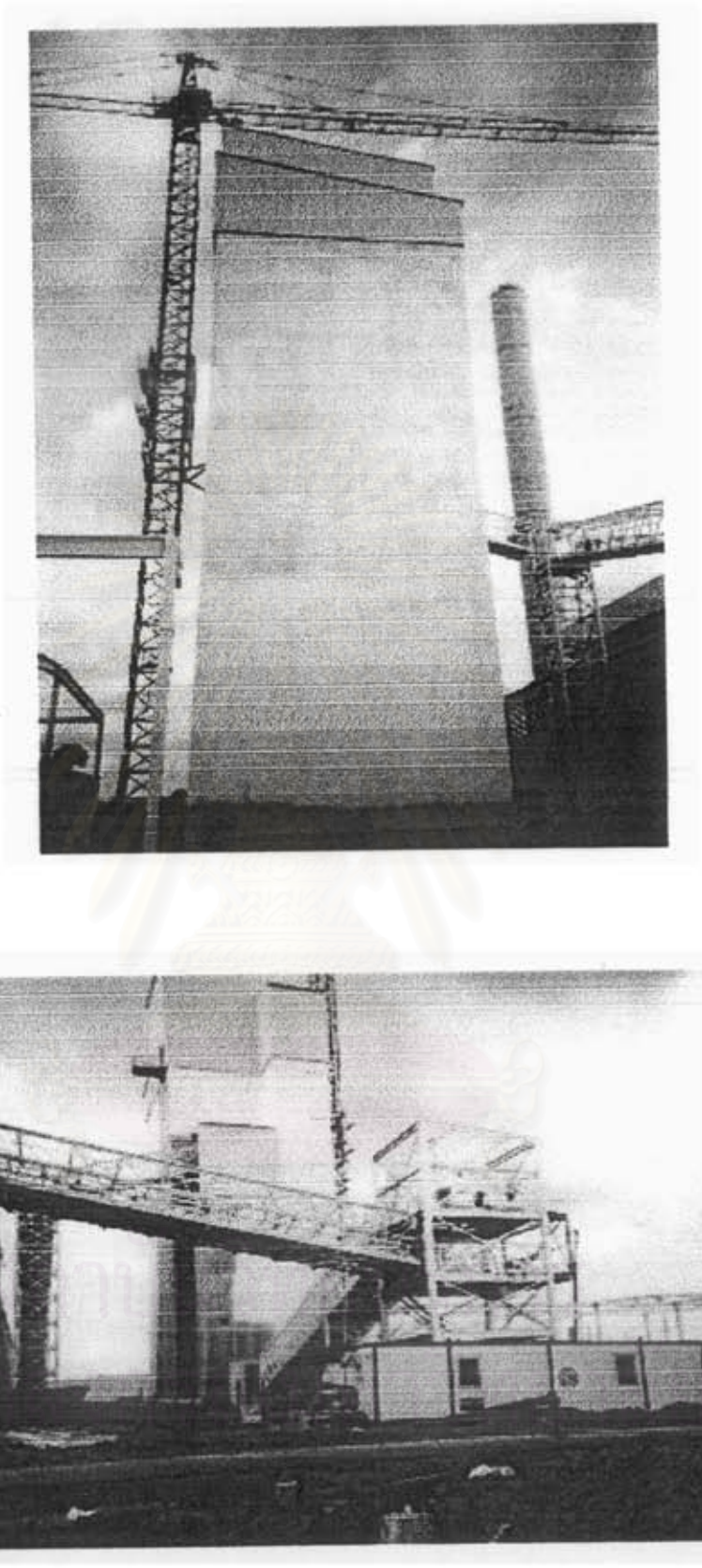


Figure 4.4 Batch House

Figure 4.5 Mixed Batch Building

Figure 4.6 Raw Material Building

Figure 4.7 Furnace & Blower Room

Figure 4.8 Utility Building

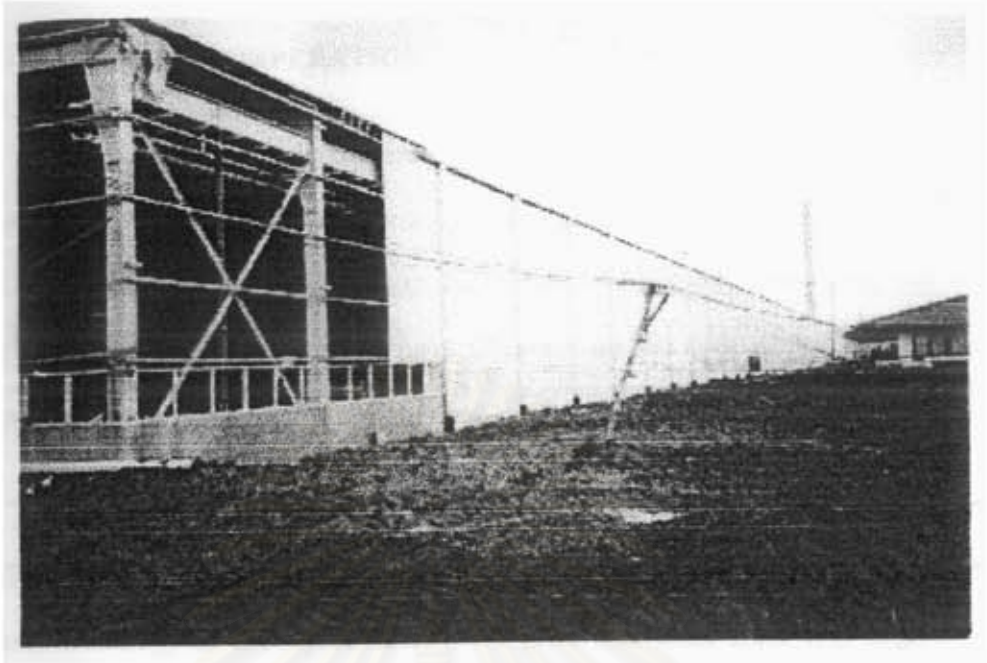


Figure 4.9 Warehouse

Figure 4.10 Main Office

4.3 PROBLEMS AND DISADVANTAGES FROM THE EXISTING SYSTEM

4.3.1 LACK OF THE COORPERATION IN EACH DESIGN GROUPS

In the existing system, each junior designer was responsible for his own works that his chief assign to him. He hardly knowed about over all propose of the project. This causes the uncoorperated feeling with the work. Moreover, there was not a good coorperation among designers. Everyone pays attention on his own work. This will cause some problems for the over all works.

EXAMPLE : Normally, the assigned works will be seperated into concrete design part and steel design part. They are distributed to seperated engineers eventhough they are in the same building. In C Project, there were problems from these two engineers. In order to design concrete column, concrete designer had to know the steel frame column size from the steel designer. Sometimes, both of them still designed their own works without coorperation in the design group. While the steel designer had changed the design by increasing size of column, the concrete designer still designed his own work with unupdated data. At the end of work, when they compared the drawings together, they found some miss-match drawing. It caused the delayed drawings, the unpleasure from the client, the man-power in re- calculation, the increasing budget, and the effect of other work groups such as the construction at site. The cost estimation of drawing correction is as follow :

Concrete Engineer*	1	person	1	day	58,500/22	=	2,659 Baht
CAD Operators*	1	person	1	day	31,200/22	=	1,418 Baht
Drawing AO size**	1	sheet					80
Total							4,157 Baht

*see table 4.1 ** see table 4.2

4.3.2 LACK OF THE COORPERATION AMONG THE DESIGN GROUPS

In the existing system, each design group also lacked of coorperation with others. There were many kinds of works that need the coorperation between the design groups. For example, the architectures and structural engineers had to work closely. In fact,

each department paid all attention on his own work. The designers hardly knowed about other groups' works. Then, the completed drawings from all work groups were not completely matched.

	1	2	3	4
Position	Salary (Baht)	Social Charges[1] (Baht) 35% of 1	Overhead Costs[2] (Baht) 60% of 1	Total (Baht) 1+2+3
Engineer (Junior Designer)	30,000	10,500	18,000	58,500
Architecture (Junior Designer)	30,000	10,500	18,000	58,500
CAD operator	16,000	5,600	9,600	31,200
Secretary	17,000	5,950	10,200	33,150
Clerk	10,000	3,500	6,000	19,500
Driver and Messenger	6,500	2,275	3,900	12,675

Table 4.1 Remuneration of A Engineering Consultants Co., Ltd.

1 see "Breakdown of Social Charge for B Co., Ltd." Figure 4.14

2 see "Breakdown of Overhead for B Co., Ltd." Figure 4.15

EXAMPLE I : The relation between Structural work group and Architectural work group is always in problems because of not enough coorperation. In C Project, the problem that occured between these two groups was the difference in elevation of the building. The clearance from floor to floor was speced by architectural work group but designed proportion by structural work group. This was the big problem when finished drawings were produced without coorperated check again. The cost estimation for correcting engineering drawings and architectural drawings is as follow :

Structural Engineer*	1	person	1	day	58,500/22	=	2,659 Baht
Architect*	1	person	1	day	58,500/22	=	2,659 Baht
CAD Operators*	2	person	1	day	2x31,200/22	=	2,837 Baht
Drawing AO size**	2	sheets			2x80	=	160 Baht
Total							8,315 Baht

*see table 4.1 ** see table 4.2

EXAMPLE II : The relation between Structural work group and Mechanical work group is always in problem too. In C Project, the problem for these two work groups was the clear space from ceiling to bottom of beam which was not enough for the piping or duct calculated from the mechanical work group. While the process of designing still ran, the problem in this point was still not solved by cross-checking. In final, when the drawings were produced, the machanical designer asked structural designer and architect for changing the clear space or preparing the beam hole for their duct which made many problems to other concerned work groups. All of these problems caused the delayed drawings, the increasing budget, the big correction by concerned designers, and the great problem if the structural drawings were sent to the site and those structures had been already constructed. The cost estimation for correcting architectural, structural mechanical drawings is as follow :

Structural Engineer*	1	person	1	day	58,500/22	=	2,659 Baht
Architect*	1	person	1	day	58,500/22	=	2,659 Baht
Mechanical Engineer*	1	person	1	day	58,500/22	=	2,659 Baht
CAD Operators*	2	person	1	day	2x31,200/22	=	2,837 Baht
Drawing AO size**	3	sheets			2x80	=	240 Baht
Total							11,054 Bath

*see table 4.1 ** see table 4.2

4.3.3 LACK OF DRAWING STANDARD

In the existing system, each work group had developed its own standard of drawing such as drawing title block, drawing numbering system, drawing sheet, and list of the running standard drawings. These differences in format of drawings caused the client to be very confused when he studied the overall drawings. Moreover, it was difficult for the designers to check or revise the drawings. These caused the problems in the construction, the wasted time and cost in order to adjust these drawings in the same standard.

EXAMPLE : These are the examples of problems which caused by no drawing standard from C Project.

1. Some drawings were missed the number of reference drawings. For example, the first floor drawing must indicate the numbers and names of drawings which showed the details of beam, column, etc. Without these reference number, it was very difficult for the client to study these drawings.

2. The names of drawing including project name, building or structure name, and drawing number were not in the same format eventhough they were in the same project and same building. They were used in the different styles so they caused a lot of problems when they were compared together.

3. The arrangement of the details in title block was not in the same format.

4. The running revision number in the revised drawings sometimes was in the numerical system and sometimes in the alphabet system.

5. The purpose of drawing sent out was not exactly indicated that it was for preliminary, information, review, approving, or construction.

6. Some drawings did not have the name of CAD operator who produced the drawing file. This caused the wasted times to find one who made this work if the designer would like to revise the drawings.

7. Some drawings did not show the electronic file name. Moreover, some electronic files were arbritary named by CAD operators. It was difficult for other CAD operators to find these files in computer if the owner of these files were not in the company.

The costs for drawing printing are as follow :

AO	size	80	Baht
A1	size	50	Baht
A2	size	40	Baht
A3	size	30	Baht
A4	size	5	Baht

Table 4.2 Cost for Drawing Printing from A Engineering Consultants Co., Ltd.

4.3.4 LACK OF FORMAL TECHNICAL CHECK

In the existing system, the technical checking procedure was performed by the chief designers. Normally, there were two checking procedures in design process. They were "preliminary drawing checking" after preliminary design and "detail drawing checking" after detail design. The chief designer himself checked the drawings of his group.

Each chief designer had his own method and concept in his checking procedure. Some chief designers checked every items thoroughly while others checked only the main items. The company did not developed the standard items for everyone to follow.

EXAMPLE : In C Project, there were some errors in the drawings and calculation sheets. The clients complained about the quality of design works. For example, the sizes of horizontal member and vertical member were not in the appropriate proportion.

The errors in drawings especially in engineering term might cause a severe problem. For example, the number of bolts in each connection was missed. There were many types of connections in steel connection drawings. Each connection had a lot of bolts. A CAD operator missed some bolts. If the chief designer had not checked the drawings thoroughly and let they be issued to the construction site, the connection would have been constructed according to this drawings. This connection might be collapsed after the machine was installed.

Besides the items in the drawings, the clients also complained about other items such as cost, constructability, etc. For some chief designers, they paid all attention to the strength of structure but the cost of the structure type which he selected was so high. The clients preferred other structure types which were strong enough to operate the work and could save a lot of money. They asked the project manager whether these items (cost, constructability, etc.) had already been considered. The project manager could not explain to him clearly because he did not have any documents which showed the checking items from the chief designers.

4.3.5 LACK OF MINOR CHECKING

In existing system, the calculation and drawing checking were performed when they were made completely. In process of drawing production, the calculations were prepared by designers. After that, the drawings were prepared by CAD-operators which got the information from draft drawings of designers. The complete drawing was checked by the junior designers one time before sending these calculations and drawings to re-check again. The chief designer re-checked them for a while. This duration took a long time because he had never checked in the design procedure or in the drafting procedure. After that, the junior designers changed their drawings according to their chief's comments and corrections. Sometimes, this re-work process took a lot of time and money in order to re-print the drawings. This problem wasted the time, human resource, and company resource.

EXAMPLE : In C Project, the junior designer had designed the slab of Furnace and Tin Bath Building by using different types of structure. One part was slab on beam. The other part was flat slab. After all of these drawings were completed, all of them were sent to the chief designer to be checked. The chief designer would like to change the types of slab structure to be the same type. He preferred flat slab because it was more stable. In this case, a lot of drawings had to be changed. A cost estimation for correcting these drawings was as follow :

Structural Engineer*	2	persons	1	day	2x58,500/22	=	5,318 Baht
Architect*	1	person	1	day	58,500/22	=	2,659 Baht
CAD Operators*	3	persons	1	day	3x31,500/22	=	4,295 Baht
Drawings AO Size**							
- Structural Drawings	4	sheets			4x80	=	320 Baht
- Architectural Drawings	2	sheets			2x80	=	160 Baht
Total							12,752 Baht

* see table 4.1

** see table 4.2

4.3.6 LACK OF THE CALCULATION STANDARD AND DESIGN CRITERIA

In the design process, the chief designer distributed works to junior designers to design each part of structure. Each junior designers set design criteria by himself. Sometimes, he missed the main criteria of work or design code that the client or local rules require. These made the mistaken parts of calculation and the inappropriate sizes of design items.

These design criteria and calculation sheets were in different styles. Each designer developed his own standard. It was difficult to study and investigate.

EXAMPLE : In C Project, one junior designers had the responsibility to design the steel-roof structure and another designer had to design the concrete structure. In design criteria of this project, the client would like to use "working strength design method" for steel structure and "ultimate strength design method" for concrete structure. The concrete designer missed this concept and thought that the steel designers used the same method as him. Thus, he used the estimated load from steel structure to design column and foundation without adjusting the factors of input load. Consequently, the size of concrete structure was smaller than it should be.

Moreover, the calculation sheets were also not in the same standard. Each engineer had his own style. It was difficult for both chief engineer and clients to study these calculation sheets.

4.3.7 EACH DESIGNER MAKES A CONCEPTUAL DESIGN INDIVIDUALLY

In existing system, each junior designer started the preliminary design after he had receiveed the data from his chief. Although there were not any errors in preliminary design process, the drawings from each designer might not be matched in term of technique. The reason is that the chief designer did not set the concepts of design for them so each designer designed in different ways.

EXAMPLE : In C Project, there are two buildings which had the same objectives in using them. These two buildings were designed by different structural

engineers. One engineer used a slab on beam as a floor system. Other used flat slab as a floor system. These two building should use the same structural type. After the senior engineer had checked all drawings, ones had to changed to slab on beam system. The foundation drawings were also effected from this changed. The total number of adjusted drawings was 6 sheets. The cost for adjusted these drawings is as follow:

Structural Engineer*	1	person	2	days	2x58,500/22	=	5,318 Baht
CAD operators*	1	person	2	days	2x31,200/22	=	2,837 Baht
Drawing AO size**	6	sheets			6x80	=	480 Baht
Total							8,635 Bath

*see table 4.1 ** see table 4.2

4.3.8 THE SUPPORTED TEAM HAS VARIOUS TYPES OF WORK

In existing system, all departments used the same supported team. For example, one CAD operators had to do many types of work such as structure, electrical sanitary, etc. Some of these works have only a little relationship. So, the CAD operators could not work effectively. They had to adjust themselves all the time. They did not have high skills in any types of works. If they did only related works such as structural work and architectural work, they could work more effectively.

4.3.9 THE PROJECT MANAGER HAS TOO MUCH RESPONSIBILITIES

The project manager was a key person. In the existing system, he had the administrative work, external coordination work, internal coordination work and in the same time, he maintained the work schedule. Consequently, he could not work effectively in every responsibilities. For example, he had to prepare the progress report for the clients and join the meeting with them to get some necessary information. Thus, he hardly had time to solve some problems arising during the design process. Moreover, if he had been absent, all works could not have been smoothly performed.

The project manager also took responsibility to collect all drawings and sent them to the clients. Because he had a lot of work to do, he did not have time to check all the drawings from every departments thoroughly. The clients blamed on the company.

Too much responsibilities of project manager caused a lot of problems. The company lost both time and money. Some processes took a longer time than they should because the project manager did not have time to perform them.

4.3.10 LACK OF CERTAIN DESIGN PROCEDURE

In design process, everyone performed the work in the way which they were used to. Thus, the work procedure for each person was quite different. For example, if junior designers would like to get more data, someone asked for them from the chief designers. Someone, who had good relationship with the project manager, asked for them from the project manager. Sometimes, the data from chief designer and project manager were different although they were in the same topic.

It was also difficult for new persons in the company. They did not know the work procedure step by step. It took quite a long time for them to learn the system of the company.

4.3.11 LACK OF DIRECT COMMUNICATION BETWEEN SUPERVISING PERSONS AND DESIGNERS

In construction site, the contractors and supervising person could not understand all of the drawings clearly. They had to ask for some explanations from the designers. They sent these questions to project manager and then he distributed them to the concerned designers.

The drawing revising was in the same process. The contractors sent their proposed drawings to project manager to distribute to chief engineers in the office for their approval. The site engineers sent the drawings of structures which had been added in construction site to the project manager to add them in the company drawings. It took quite a long time to approve the contractors' drawings and revised the drawings according to the site

engineers. After receive these drawings, the chief engineers sent all of these drawings to all concerned designers to manage them. After that, the designers sent their product back to their chiefs. For approving the proposed drawings of contractors, the designers made the calculation and sent their decision to their chief. He considered it again before issuing it to the contractor. For drawing revising, the designers adjusted their drawings after they had received the information from their chief. Then, they sent these drawings to their chief to send them to the site engineers.

There was no direct communication between supervising persons and designers. Their communication depended on the project manager or chief designers. So the process of drawing approval and drawing revision take longer time than they should.

4.3.12 LACK OF CLEAR CONCLUSION ABOUT THE RESPONSIBILITIES OF EACH COMPANY FOR SUPERVISION WORKS

One problems which always occurs in construction site is the responsibilities for each company. There are at least three companies in construction site, the Contractor, the Owner and the Consultant company. In the existing system, every company tried to deny the responsibility to manage some problems or to pay money for compensation from those problems.

EXAMPLE : In C Project, A staff got an accident during supervision work. A asked the contractors to pay compensation to this person. The contractor did not accept this request. They explained that they did not need to be responsible for the insurance of the consultant company.

This confliction would have not occurred if there had been a clear conclusion about the responsibilites of each company. This topic should be discussed in the meeting before starting the construction work.

4.4 DISADVANTAGES FROM EXISTING SYSTEM IN C PROJECT

4.4.1 TOTAL COST FOR DRAWINGS CORRECTION IN C PROJECT

Because of problems and disadvantages from existing system, a lot of drawings had to be corrected. For C Project, the chief of CAD operators have recorded the number of corrected drawings. Thus, the cost of drawings correction can be calculated based on that record.

Problem : Senior Structural Engineer changed design concept in Furnace and Tin Bath Building.

Drawings:
1. Piling Plan Area "A" (Structure)
2. Footing Plan Area "A" (Structure)
3. Footing Detailed (Structure)

Costs :							
1. Concrete Engineer	1 person	2 days	2x58,500/22	=	5,318	Baht
2. CAD Operators	1 person	1 day	31,200/22	=	1,418	Baht
3. Drawing AO size	3 sheets		3x80	=	240	Baht
Total					6,976	Baht

Problem : Senior Structural Engineer changed design concept in Utility Building.

Drawings:
1. Ground Floor Plan (Structure)
2. Hot & Cold Well (Structure)
3. Section & Details (1) (Structure)
4. Section & Details (2) (Structure)
5. Ground Floor Plan EL. 60-63 (Structure)
6. Generation Room & Substation Room Ground Floor Plan (Structure)

Costs :							
1. Concrete Engineer	2 persons	2 days	2x2x58,500/22			
2. CAD Operators	2 persons	1 days	2x31,200/22	=	2,836	Baht
3. Drawing AO size	6 sheets		6x80	=	480	Baht
Total					13,952	Baht

Problem : Lack of Formal Technical Check

Drawings:
1. Anchor Bolts Details (Structural)
2. Chimney Connection to Deep Furnace (Structural)
3. Furnace Control Room & Detail (Structural)
4. Expansion Joint, Anchor Bolts for Cullet Tunnel (Structural)
5. Detail Frame 1, 2, 3 of Utility Building (Structural)
6. Footing Plan, Wall Plan Section & Detail (Structural)
7. Cutting Oil Tank & Pipe Plan and Detail (Structural)

Costs :
1. Concrete Engineer 1 person 2 days 2x58,500/22 = 5,318 Baht
2. Steel Engineer 1 person 2.5 days 2.5x58,500/22 = 6,648 Baht
3. CAD Operators 2 persons 1.5 days 2x1.5x31,200/22 = 4,255 Baht
4. Drawing AO size 7 sheets 7x80 = 560 Baht

Total 16,781 Baht

Problem : Lack of Minor Check

Drawings:
1. Shallow Basement & Tin Bath Plan (Structure)
2. Section 1, 2, 3, 4 (Structure)
3. Section 5, 6 (Structure)

Costs :
1. Concrete Engineer 1 person 2 days 2x58,500/22 = 5,318 Baht
2. CAD Operators 1 person 1 day 31,200/22 = 1,418 Baht
3. Drawing AO size 3 sheets 3x80 = 240 Baht

Total 6,976 Baht

Problem : Lack of Minor Check

Drawings:
1. Cullet Tunnel Plan (2) (Structure)
2. Cullet Tunnel Plan (3) (Structure)
3. Cullet Tunnel Plan, Section at Grid line 9 (Structure)
4. Slab Plan & Roof Plan of C.T. at Grid Line 91 (Structure)
5. Cullet Tunnel Section 25-25, 26-26 (Structure)
6. Cullet Tunnel Section 27-27, 28-28, 29-29, 30-30 (Structure)
7. Cullet Tunnel Section 33-33, 34-34, Detail "H", Detail "K" (Structure)

Costs : 1. Concrete Engineer 2 persons 2 days 2x2.5x58,500/22 = 13,925 Baht
2. CAD Operator 2 persons 2.5 days 2x2.5x31,200/22 = 7,091 Baht
3. Drawing AO size 7 sheets 7x80 = 560 Baht
Total 21,576 Baht

Problem : Lack of the cooperation in each design group

Drawing : Column and Base Plate Details (Structural)

Costs : 1. Concrete Engineer 1 person 1 day 58,500/22 = 2,659 Baht
2. CAD Operators 1 person 0.5 day 0.5x31,200/22 = 709 Baht
3. Drawing AO size 1 sheet 1x80 = 80 Baht
Total 3,448 Baht

Problem : Lack of the cooperation in each design group

Drawing : Pump Foundation Plan and Section (Structural)

Costs : 1. Concrete Engineer 1 person 1 day 58,500/22 = 2,659 Baht
2. CAD Operators 1 person 1 day 31,200/22 = 1,418 Baht
3. Drawing AO size 1 sheet 1x80 = 80 Baht
Total 4,157 Baht

Problem : Lack of the coopreation among the design groups

Drawing : 1. Side Wall Elevation Sheet 1 (Structural)
2. Side Wall Elevation Sheet 2 (Structural)

Costs : 1. Structural Engineer 1 person 1 day 58,500/22 = 2,659 Baht
2. Architect 1 person 1 day 58,500/22 = 2,659 Baht
3. CAD Operator 2 person 1 day 2x31,200/22 = 2,837 Baht
4. Drawing AO size 2 sheets 2x80 = 160 Baht
Total 8,315 Baht

Problem : Lack of the cooperation among the design groups

Drawing : 1. Elevation of Batch Bin Support (Structural)
2. Batch Bin Support Elevation Plan (Architecture)
3. Mechanical details (Mechanical)

Costs :	1. Structural Engineer	1	person	1	day	58,500/22	=2,659	Baht
	2. Architect	1	person	1	day	58,500/22	=2,659	Baht
	3. Mechanical Engineer	1	person	1	day	58,500/22	=2,659	Baht
	4. CAD Operator	2	persons	1	day	2x31,200/22	=2,837	Baht
	5. Drawing AO size	3	sheets			3x80	= 240	Baht
	Total						11,054	Baht

Problem : Lack of Drawing Standard

Drawings:	1. Reinforce Section	1.1, 2, 3, 4	(Structure)
	2. Reinforce Section	5, 6	(Structure)
	3. Reinforce Section	7	(Structure)
	4. Reinforce Section	8	(Structure)
	5. Reinforce Section	9	(Structure)
	6. Reinforce Section	10	(Structure)
	7. Reinforce Section	11, 12, 13	(Structure)
	8. Reinforce Section	14, 15	(Structure)
	9. Reinforce Section	16, 17, 18	(Structure)

Costs :	1. Structural Engineer	1	person	2	days	2x58,500/22	=5,318	Baht
	2. CAD Operator	1	person	2	days	2x31,200/22	=2,836	Baht
	5. Drawing AO size	9	sheets			9x80	= 720	Baht
	Total						8,874	Baht

Thus, the total cost for drawing correction is 102, 109 Baht.

4.4.2 DELAYED TIME

In the schedule of C Project, the total time to complete the design work and supervision work is **twenty one months**. This project began in **October, 1995**. According to the schedule, the design work must be completed in **January, 1996** and supervision work should be completed in **June, 1997**.

In practical, the design work was finished in **March, 1996.** It took two months more than schedule. The supervision work was completed in **September, 1997.** It was **three** months lated.

This lated time cause the expense of A for this project higher than estimated cost. The profits was than expected. The owner had to canceled his schedule to start the producting process. A cannot satisfy his need.

There are many reason that the project cannot be completed in time. For example, a lot of corrections in design process, client took quite a long time for drawings approval, lack of communication among A's departments, the problems in construction site between A and contractors.

4.4.3 CLIENT'S UNSATISFACTION ABOUT THE DRAWING QUALITY

Besides a lot of drawings had to be corrected because of technical reasons, many drawings were not be satisfied by the client because of their quality. The client often claimed about the standard of drawing format, confusing drawing number and electronic file names, the different layers of drawings in electronic file, etc. Although A did not need to re-produce all of these drawings, it must make some minor correction for every drawings. It also caused the unsatisfaction of the client. A lost its face when the client claimed about these problems.

4.4.4 LOSING TRUST FROM THE CLIENTS

In engineering consulting business, the image of the companies and trust from the clients are very important. Especially in factory projects, the budget is high and the mistakes may cause a severe problems such as factory collapse, machine damage, death of workman. If the clients do not believe in that consultant company, they never allow it to design and supervise their factories.

For C Project, although there were not any severe problems during the construction, the drawings were corrected many times. The calculation sheets and drawings were difficult to study. The conflictions between A and contractors often occurred. Consequently, the client was not impressed in the works of A. The image of DEC is not good. The clients may be hestitate for allowing A to be their consultant in other new projects.

These disadvantages cannot be calculated in term of money but they have a lot of impacts on A. It may lose the opportunity to get new projects and cannot survive in high competitive market.

These disadvantages will be reduced in developed system. The standard of drawings, design criteria, conceptual design and checking system will be used in order to solve these problems.

4.5 THE DEVELOPED SYSTEM

Normally, the board types of works that A Engineering Consultants Co., Ltd. undertakes may generally be categorized into Design Work and Construction Supervision/Management Work. The work procedures of them are not effective for competing in international market. A has to improve its work procedures. The developed work procedures are discussed as follow :

4.5.1 DESIGN WORK

I. Scope of Works

The scope of the Design Work may be broadly devided into three groups which are shown below.

Conceptual Design

Preliminary Design

Detailed Design

Each of the above groups has different items of works which must be done by DEC. These are to be identified clearly.

(A) Conceptual Design

Responsible person : The chief designers.

Product : The chief designers' Conceptual Design Conclusion in term of report and roughly sketched drawings.

In order to get new project from the client, A has to prepare the technical proposal and financial proposal for the client. In technical proposal, A has to provide some proposed design such as the model of the building, the rough lay-out of the factories. Almost all of proposed design is architectural works. If these proprosals satisfy the client, A can get that project. The proposed design will be developed into conceptual design.

The work in Conceptual Design is to make a design concept for each building. After the kick-off meeting with the clients and internal meeting among departments, each chief designer has to study the proposed design characteristics of each buildings. Then, he sets a design criteria for his own group and select the most suitable structure and system for each buildings. All of chief designers have to discuss to one another about their decisions in order that there are not any conflicts between departments.

EXAMPLE : In structural group, the chief designer has to discuss with the clients in kick-off meeting about their needs. Then, he has to study the characteristics of each building and discuss with other chief designers in internal meeting before set a design criteria by using the standard form. He has to select the most suitable type of structure for each building. For example, in warehouse building, the type of slab structure should be the slab on ground. The roof structure should be a steel structure. In this stage, the chief designer is not necessary to make any calculation sheet or formal drawings. He just only writes his concept down in the reports and makes some roughly sketched drawings as necessary. After that, these design criteria and conceptual designs will be distributed to their concerned designers to make the preliminary design.

(B) Preliminary Design

Responsible person : The chief designers, Junior designers, CAD operators.

Product : Preliminary drawings, Calculation Sheets, Preliminary Cost Estimation.

The work in Preliminary Design is to make some drawings and calculations to demonstrate the figures and sizes of structures and systems to the clients. Besides the drawings and calculation sheets, the construction cost estimation is also determined in this stage. The objection of the Preliminary Design is to let the client see the figure, the system and construction cost of each building. It is not necessary to calculate and make drawings for every items of the buildings. Some unnecessary items such as detailed of steel cover sheet, etc. can be neglected. These items will be designed in detailed design.

EXAMPLE : In structural group, each junior designer has to study the design criteria and conceptual design reports from his chief. After that, he begins his design work. He has to determine the size and length of pile, the size of beam and column, the thickness of slab according to the conceptual design. For superstructure, the member sizes of main truss and secondary truss, size of purlin, etc. are determined. Some structural details such as sizes and number of bolts in steel connections, base plates for steel columns are neglected in this stage. After CAD operation and junior engineer checking, all of these drawings and calculation sheets are sent to the chief structural engineer to check.

(C) Detailed Design

Responsible person : The chief designer, Junior designers and CAD operators.

Product : Drawings, Calculation Sheets and Construction Cost Estimation.

In this stage, all of necessary items must be designed. Every details are shown in drawings. The objection of this design stage is to make the calculation sheets and drawings which have details enough for bidding and construction. The construction cost estimation must be thoroughly determined in order to get the exact cost.

EXAMPLE : In structural group, after the clients have approved the preliminary design, the structural engineers begin their detailed design works based on the preliminary design. In this stage, every details have to be calculated and shown in drawings. Many drawings have been added to show the necessary details such as steel connection details, steel cover sheet details, colum base plates details and reinforcement at connection between slab and ground beam details. The Technical checking and Quality checking must be being performed while the design work is being done.

II. Design Work Procedure

The design work procedure should be improved from the existing system. The organization chart, design criterias, standards of drawings and calculation sheets should be improved. The formal Technical check and Quality check are developed. The new design work procedure is as follow.

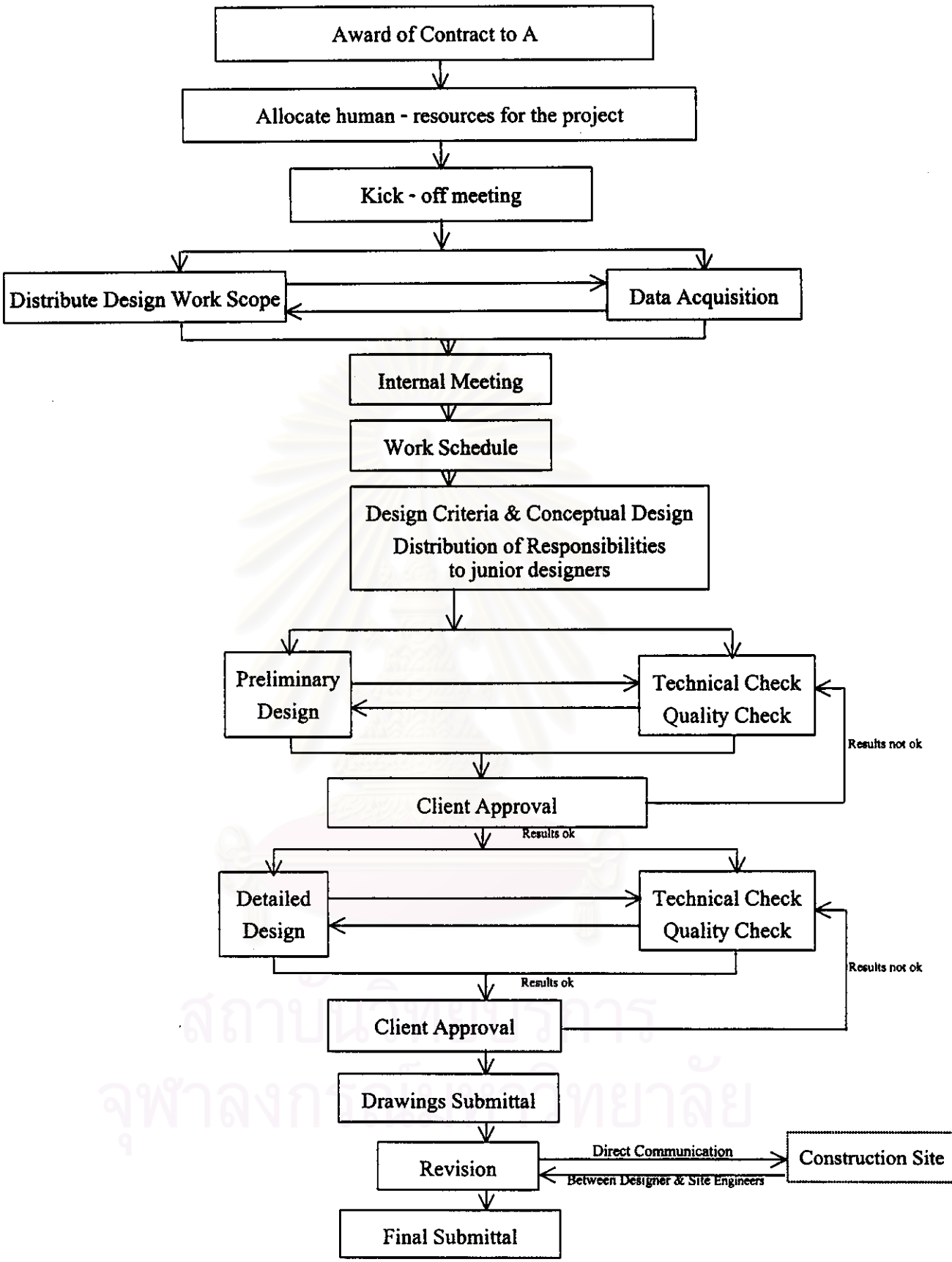


Figure 4.11 Developed Design Procedure

A) Allocate Human-Resources for the projects

A has to choose two senior persons to be the Project Manager and Project Advisors. Then, the Project Manager set his team by selecting people for concerned departments. An organization chart is prepared to show the project staffs and their responsibilities. The chart will be prepared according to the requirements of the particular project. Responsibilities of the project personnel related to the design works are as follow :

Project Advisor

Responsibility: Advise on the project.

Project Manager

Responsibility:

(a) **Administrative**

1. The decision making person of the project on behalf of the Consultant.
2. Administrative matters of the project staff of consultant companies.
3. Authorizing officer of the project expenditures of consultant companies.

(b) **General**

4. Authorization officer for the design drawings.
5. Prepare the Project Organization Chart in consultation with the Project Advisor.
6. Arrange and conduct the kick-off meeting.

(c) **External Coordination**

7. Coordinate with the client or his representative.
8. Obtain necessary information and data from the Client.
9. Transmit the information and data obtained from the client to the Project Coordinator for distribution to the designers concerned.
10. Obtain the work schedules from individual disciplines and prepare the work schedule for the project.

11. Revise the project schedule as and when necessary.
12. Feed back to the Project Coordinator for internal coordinator.

***(d)* Progress of Work**

13. Arrange progress meetings as and when necessary
14. Prepare the Progress Reports and transmit to the client, when necessary.
15. See that the design works are proceeding according to the work schedule.
16. Arrange to solve the problems arising during the progress of the design works.
17. Prepare the drawing list for the project.
18. Manage all the changed orders and additional works, if applicable.
19. Help the Accounting Department to prepare the invoices and supply necessary data in this connection.
20. Follow up the payment from the client.

Project Coordinator

Responsibility:

1. Coordinate the technical works of all the disciplines involved in the design work.
2. Obtain the information and data from the Project Manager and distribute to the designers concerned.
3. Help the designers to obtain the technical data and information.
4. Help the Project Manager in all technical matters of the design works being done by the designers.
5. Work as the Project Manager when the Project Manager is away.
6. Arrange the technical checks of the design drawings.
7. Arrange the quality checks for the design drawings to be transmitted to the Client.

Chief Designers

Responsibility:

1) Full responsibility of the design works (professionally)
2) Assigning responsibilities to one or more designer engineer(s) for the design work of the project.
3) Perform part of the design work as necessary.
4) Supervise the works of the his group.
5) Obtain information and data and feed to the concerned designers.
6) Maintain work schedule.
7) Maintain close liaison with the Project
8) Manager/Coordinator.
9) Prepare and submit reports as and when required.

Designers

Responsibility :

1) Perform the design work as per requirements of the project and guidance of the Chief Designer.
2) Production of the drawings.

CAD Operators

Responsibility : Production of drawings.

Secretaries

Responsibility : Secretarial works of the project.

Other Staff

Responsibility : Responsibility as assigned by the Project Manager

The supported staff such as CAD operators, secretaries, etc should be devided in to two groups. One group for architectural, structural and civil works. Other for electrical, mechanical and sanitary work. These two groups are devided according to the characteristics of their works. The works of structure, architect and civil has a close relationship. They are

related to the shape, figure and structure of building. For the electrical, mechanical and sanitary works, they are related to the electrical and piping works of building. They are called system work. If the works are devided into these two groups, the supported team can work more effectively because they can concentrate on the related work.

The organization chart is shown in next page.

B) Kick off Meeting

Responsible person : Project manager, Project coordinator, Project advisor, Chief designers, Client, Secretary

Before starting the design work, generally a kick off meeting is held. This is attended by the representative of the client, project manager and other professionals such as project advisors, project coordinators and chief designers from every departments concerned. The Project Orientation is done in this meeting in which responsibilities between the client and the consultants are identified. There are a lot of detailed responsibilities to be carried out to complete the design work. A standard form showing the sharing of these responsibilities is not feasible because each client has his own terms and conditions for his project. However, a reference format will be used for guidance. For each project, a reference format may be prepared.

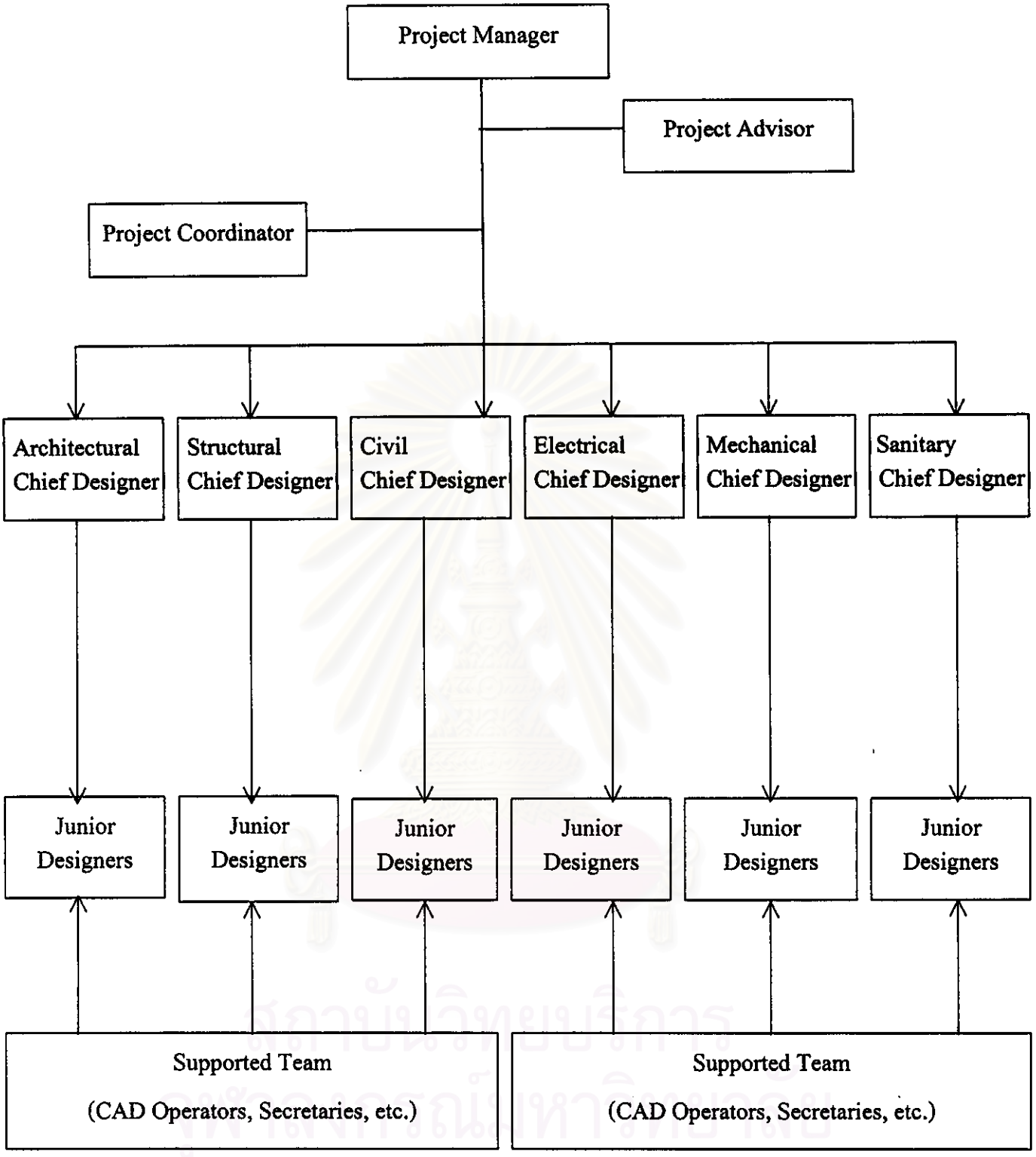


Figure 4.12 Developed Design Team Organization Chart

Furthermore, all of essential data are provided by the client. The chief designers have to ask for any essential data such as the client's requirements for the details of building, the loading details, the units and standard codes, etc. The chief designers should discuss with the client about the characteristics, figures and structural types of each building in order that their conceptual design will meet the client's needs.

Some clients have their own standards of drawings and calculation sheets, these data must be provided to A. Local rules and regulations must also be provided if the project is in up-country or out of Thailands.

C) Design Work Scope

Responsible person : Project manager, Secretary

After the Kick of meeting, all of basic data should be concluded in standard form so that all concerned persons can understand the over all project. The standard form contains the following information. All of them may not be required for all projects.

General scope
General characteristics of facilities
Volume of construction work
Basis of design
Scopes of design / documents to be produced
Highlights

This design work scope will be issued to all concerned persons by the Project manager. Any particular data received later from the client will be sent to the concerned person through a revised design work scope.

The example of Design Work Scope Form is shown in next page

A ENGINEERING CONSULTANTS CO., LTD.

DESIGN WORK SCOPE

Project : _____	**Date :** _____
JOB NO. _____	**Rev.** _____
Structural Engineering Departments	**Chief Design** _____

1. GENERAL SCOPE

2. GENERAL CHARACTERISTICS OF FACILITIES

3. VOLUME OF CONSTRUCTION WORK

4. SITE COORDINATION SCHEDULE

5. BASIS OF DESIGN

6. SCOPE OF DESIGN/DOCUMENTS TO BE PROCUCED

7. HIGHLIGHTS/NOTES

ISSUED :	**RECEIVE :**	

D) Data Acquisition

Responsible person : Chief Designers, Designers

After receiving Design Work Scope, each chief designer and his team should examine in hand data whether the relevant information are available or not. If some of the required data are not available, he should ask the Project manager for the missing data. In order to examine and ask for some data, the standard form should used.

The type of works and basic data which the design team would like to get should be clearly identified. The example of details standard form for structural department is as follow:

(a) Type of works : the designers should indentify the type of works for which they required data to design. It can help the project manager to classify the data before asking the client for these data. The types of design works are classibied as follows :

Standard Drawings and general notes

Piling Work

RC Substructure (Pile cap, Footing & Structure below Ground Floor)

RC Superstructure (Ground floor and Above structure)

Steel Structure (Sheet Piling, etc.)

Steel Superstructure

(b) Basic data : The chief designers should examine their data according to the following items. Then, they can identify the missing ones.

Basic Information : Units, Standard Codes, Details of Buildings/-Structures/Areas

Loading Details

Soil Investigation Report

Topography

Existing Utilities and Facilities (Electrical, drainage, Roads)

The example of this standard form for structural engineering department is in next page.

A ENGINEERING CONSULTANTS CO., LTD.

DATA ACQUISITION

Project : _____ **Date :** _____

JOB NO. _____ **Rev.** _____

Structural Engineering Departments **Chief Design** _____

1. TYPE OF WORKS

- ☐ Standard Drawings / General notes
- ☐ Piling Work
- ☐ RC Substructure
- ☐ RC Superstructure
- ☐ Steel Structure
- ☐ Steel Superstructure

Notes _____

2. BASIC DATA

- ☐ Basic Information
- ☐ Loading Details
- ☐ Soil Investigation Reports
- ☐ Topography
- ☐ Existing Utilities / Facilities

Notes _____

ISSUED :	**RECEIVE :**	

E) Internal Meeting

Responsible person : Project Manager, Project Advisor, Chief Designers.

The meeting among project manager, project advisor and chief designers from all concerned departments must be held. In this meeting, the relation of works among these departments is discussed to prevent some conflicts which may be happened during design process. Moreover, the strategies to complete design work within the client's established budget, performance and time requirements should be set in the meeting.

F) Work Schedule

Responsible person : Project Manager

Before the start of the work, a schedule shall be prepared to show the time table when a particular activity of the design will be started and when it will be completed. The client may also supply the overall schedule of the project which will act as the guideline for the design work schedule.

Based on the project requirements, the work schedule will be prepared and updated by the project manager.

G) Design Criteria & Conceptual Design, Distribution of Responsibilities

Responsible person : Chief Designers

Before distributing the work to all designers in his group, the chief designer makes the Design Criteria and Conceptual Design according to the conclusion in the kick-off meeting and Internal Meeting. Consequently, the products of his group will meet the objections of the project. The following items must be identified in Design Criteria.

Standard Codes

Local Codes of Practice

Local Rules and Regulations

This Design Criteria set is different from project to project. After preperation of the Criteria set, the Client may be kept informed.

The Conceptual Design is also prepared by the chief designer. After completing Design Criteria set and Conceptual Design, the chief designer will distribute all works to designers in his group.

H) Design and Development : Preliminary Design, Detailed Design

After receiving Conceptual Design and Design Criteria from their chief, each designer has to study his distributed work and start the Preliminary Design. If the client is satisfied his Preliminary Design, he can begin the Detailed Design.

As the design work proceeds, some additional data may be necessary. The project manager and project coordinator must try to obtain that data and provide to the designers. Some problems may also arise during the design process. Through communication, discussion or meeting, these problems can be solved. In some cases, only internal meeting within A is enough to solve those problems. In some cases, the Client may need to be involved.

The quality check and technical check must be performed every week. At the end of the week, the senior designer should check all of works which are completed in that week such as drawings, calculation sheets. It takes only half day to perform these checking because there are not so many drawings and calculation sheets completed in one week.

The certain procedure of Preliminary Design and Detailed Design is shown in term of Flow Chart in next page. This flow chart explains the step of design work and concerned people.

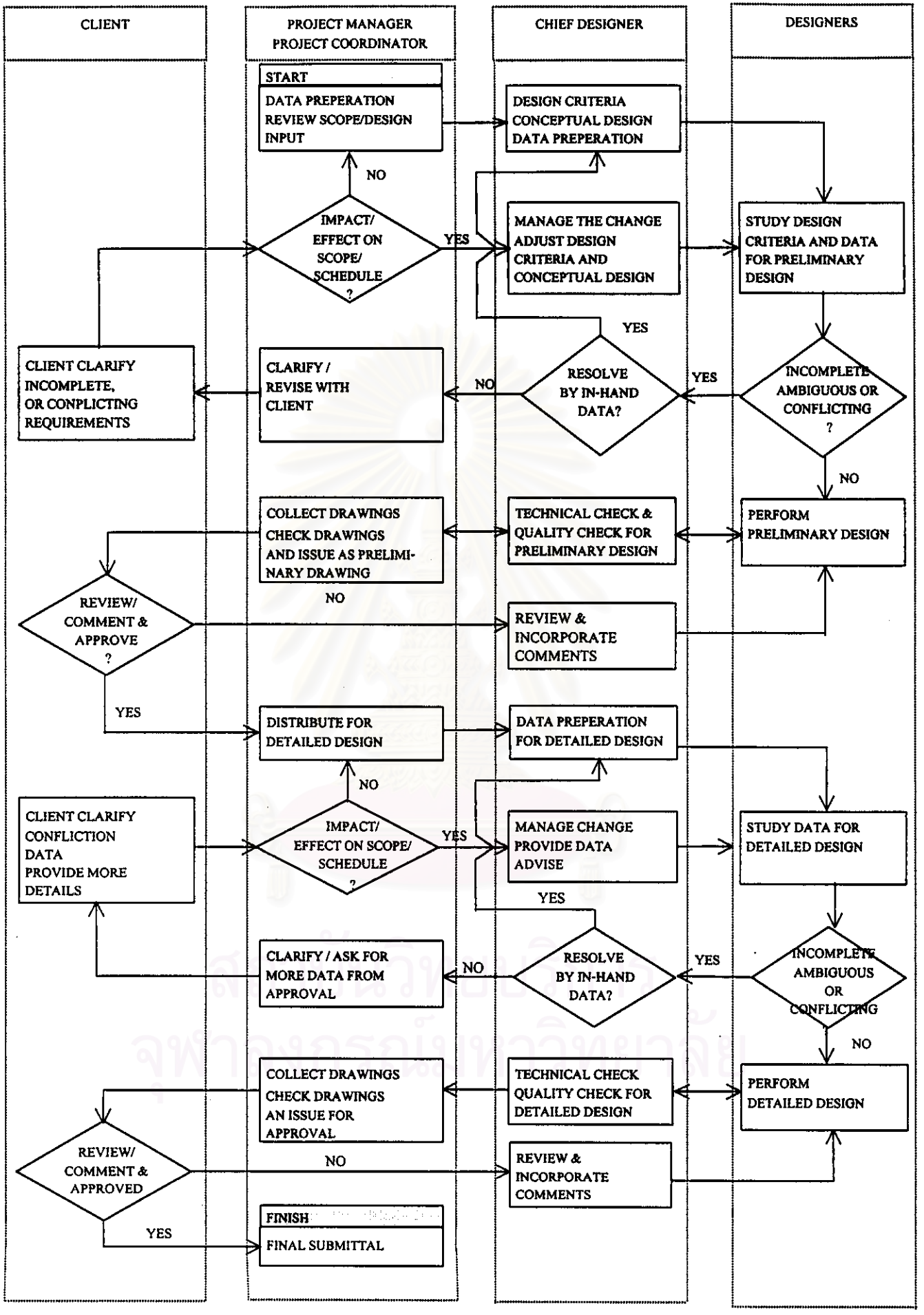


Figure 4.13 The Procedure of Preliminary Design and Detailed Design

I) Quality Check

There should be a quality control system in order to solve the problems from lack of quality checking. The company has to develop the standard of drawings and calculation sheets. All of drawings and calculation sheets have to be formally checked before sending to the clients. The items in Quality Check are as follow :

- **Standard Format**

The drawings and calculation sheets have to be in company standard. For the drawings, the numbers and the names must be in standard system. The title block of all drawings must be the same. The size and weight of the letters in the title block must not be different.

The calculation sheets must be in the same formats. Computer technology should be applied to make the company standard. For example, in structural engineering group, the calculation sheets for each types of structure should be create by computer programme such as EXCEL. Thus, it is easy for a checking person to investigate the calculation sheets. The examples of structural calculation sheets and standardization of design drawings are shown in next page.

CLIENT :	TOTAL SHEETS (INCLUDING COVER)	DISTRIBUTION
BUILDING :		
PROJECT :		
LOCATION :		

CALCULATION SHEET

OF

_____

_____

REV.	BY	DATE	CHKD.	DATE	APPD.	DATE

PURPOSE	
	INFORMATION
	PRELIMANARY
	REVIEW
	APPROVAL
	CONSTRUCTION
	AS BUILT

SPECIALIST STAMP

DEPARTMENT	PROJECT NO.	DOCUMENT NO. (SPEC. OR DWG. NO.)	REV. NO.	ISSUE DATE
STRUCTURAL			0	

1.0 SCOPE OF WORK

This calculation describes the detailed design of control building. This building will be used to control the process of glass manufacturing plant. The building will be approximately 18 meters high with a footprint of 24.0 meters by 48 meters. The walls of the building will be concrete block. The roof structure will be supported by a steel roof truss and reinforced concrete columns.

2.0 RELATED CODES AND STANDARDS

2.1 ASCE 7-95 Minimum Design Loads of Buildings and Other Structures

2.2 ACI 318-95 Building Code Requirements for Structural Concrete

2.3 AISC Manual of Steel Construction 9th Edition, Allowable Stress Design

2.4 Engineering Institute of Thailand (EIT) Codes and Regulations

3.0 MATERIALS

Concrete	Specified Compressive Strength ;	
	$f'c = 210$ kg / cm^2	for reinforced concrete
	$f'c = 140$ kg / cm^2	for lean concrete
Reinforcing bar	Specified Yield Strength of deformed bar in TIS24-2527	
	Grade SD40 ;	
	$fy = 4{,}000$ kg / cm^2	
	Specified Yield Strength of round bar in TIS20-2527	
	Grade SR24 ;	
	$fy = 2{,}400$ kg / cm^2	
Structural Steel	Specified Minimum Yield Stress of Steel in A36 or equivalent	
	(JIS G 3101 SS400) ;	
	$Fy = 2{,}400$ kg / cm^2	
Welding Electordes	AWS A70XX	
High strength bolt	ASTM A325 or equivalent (JIS 1186 F8T)	
Anchor bolt	ASTM A36 or equivalent	

4.0 DESIGN LOADS

The following load cases will be used to develop applicable factored load combinations :

1) Dead load (DL)

- Reinforced Concrete density is 2,400 kg/m^3
- Overburden wet soil density is 1,950 kg/m^3
- Floor finishing : 120 kg/m^2
- Brick wall : 220 kg/m^2

2) Live load (LL)

- Caretaker room and toilet : 300 kg/m^2
- Elec. Comm. & Instr. Room : 500 kg/m^2
- Roof : 150 kg/m^2

3) Wind load (WL)

$$p = qG_hC_p - q_h(GC_{pi})$$

where

p	=	Design wind pressure (lb/ft^2)
q	=	q_z for windward wall at height z above ground (lb/ft^2)
		q_h for leeward wall and roof evaluated at mean roof height (lb/ft^2)
G_h	=	Gust response factor given in accordance with exposure categories and height
C_p	=	External pressure coefficient for wall and roof
GC_{pi}	=	Internal pressure coefficient for buildings

Wall Pressure

- Windward Wall : $p = 21.30 \times 1.29 \times 0.8 - 21.30 \times (-0.25)$
  $= 27.31 \ lb/ft^2$
  $= 135 \ kg/m^2$
- Leeward Wall : $p = 21.30 \times 1.29 \times 0.5 - 21.30 \times (-0.25)$
  $= 19.06 \ lb/ft^2$
  $= 95 \ kg/m^2$

Roof Pressure : $p = 21.30 \times 1.29 \times 0.7 - 21.30 \times (-0.25)$
$= 24.56 \ lb/ft^2$
$= 120 \ kg/m^2$

Note : All of the data for calculation of wind pressure are from SP C-9704.20-010-009 Design criteria for civil and building work

5.0 DESIGN LOAD COMBINATIONS

Load combination will be developed with appropriate load factors for the determination of maximum load on piles and the design of structural member , as follows :

- For checking serviceability of building, load on pile and steel design

Case	Load Combination
1	DL + LL
2	DL + LL + WL
3	DL + WL

- For reinforced concrete design

Case	Load Combination
1	1.4 DL + 1.7 LL
2	0.75(1.4 DL + 1.7 (LL + WL))
3	0.9 DL + 1.3 WL

6.0 INPUT LOAD FOR STRUCTURAL ANALYSIS

7.0 METHOD OF ANALYSIS AND DESIGN

- For structural analysis and design of steel member , the computer program used is STAAD III Release 22 W.
- Reinforced concrete design will be made by using classical manual calculations and Microsoft Excel to determine the reinforcement.

8.0 DESIGN CRITERIA

Reinforced Concrete Design using Strength design method

- Flexural Strength Design

$$\rho_b = 0.85 \times \beta_1 \times \frac{fc'}{fy} \times \frac{6120}{(6120+fy)}$$

$$\beta_1 = 0.85 - 0.05 \times \frac{(fc'-280)}{70} \ ; \beta_1 \leq 0.85$$

$\rho_{max} = 0.75\rho_b$

$\rho_{min} = \frac{14}{fy}$; for beam and footing

$= 0.0018$; for slab where Grade SD40 deformed bars are used

$= 0.0025$; for slab where Grade SR24 round bars are used

$R = 0.75\,\rho_b\, fy\,(1 - 0.44\,\rho_b \frac{fy}{fc'})$

$\phi M_n = \phi R b d^2$, $\phi = 0.9$

For single reinforcement : ($M_u \leq \phi M_n$)

$\rho = 0.85 \frac{fc'}{fy} \times (1 - \sqrt{(1 - \frac{236 M_u}{\phi b d^2 fc'})}$

- Shear Strength Design

For beam shear strength

$V_c = 0.53\sqrt{fc'}\, bd$

For punching shear strength

$V_c = 1.06\sqrt{fc'}\, b_o d$

- Compressive Strength Design

$\phi P_n = 0.80\,\phi\,(0.85fc'(Ag - As) + fy\,As)$

Where

ϕ = Strength reduction factor = 0.90 for flexure

= 0.85 for shear

= 0.70 for axial compression

where

Ag = Gross area of member (cm^2)

As = Area of reinforcing steel (cm^2)

M_u = Ultimate moment (kg-m)

M_n = Nominal flexural strength (kg-m)

P_n = Nominal Compressive strength (kg)

R = Flexural resistance factor (kg/cm^2)

V_u = Ultimate shear force (kg)

V_c = Concrete shear strength (kg)

b = member width (cm)

b_o = Critical perimeter (cm)

d = Effective depth of member (cm)

fc' = Compressive strength of concrete (kg/cm^2)

fy = Yield strength of reinforcing steel (kg/cm^2)

h = Depth of member (cm)

β_1 = Concrete stress block parameter

ρ = Reinforcement ratio = As / bd

ρ_b = Balanced steel ratio

Structural Steel Design using allowable stress design method

- Allowable Flexural Stress

1. Members with Unbraced length not exceed the value of L_c

$F_b = 0.66\ Fy$

where $L_c = \dfrac{637\ b_f}{\sqrt{Fy}}$ or $\dfrac{1406000}{(d/A_f)\ Fy}$

whichever is smaller

2. Members with Unbraced length greater than L_c

when $\sqrt{\dfrac{717x10^4C_b}{Fy}} \leq \dfrac{l}{r_T} \leq \sqrt{\dfrac{3585x10^4C_b}{Fy}}$

$F_b = \left[\dfrac{2}{3} - \dfrac{Fy\,(l/r_T)^2}{10755x10^4C_b}\right] Fy \leq 0.60Fy$

when $\dfrac{l}{r_T} \leq \sqrt{\dfrac{3585x10^4C_b}{Fy}}$

$F_b = \dfrac{1195x10^4C_bFy}{(l/r_T)^2} \leq 0.60Fy$

- Allowable Shear Stress

$F_v = 0.40\ Fy$

- Allowable Compressive Stress

when $\dfrac{Kl}{r} \leq C_c$

$F_a = \dfrac{[\,1 - (Kl/r)^2 / (2C_c^2)\,]Fy}{5/8 + 3/8(Kl/r)/C_c - (Kl/r)^3/(8C_c^3)}$

where

$C_c = \sqrt{\dfrac{2\pi^2E}{Fy}}$

when $\dfrac{Kl}{r} > C_c$

$F_a = \dfrac{12\pi^2E}{23(Kl/r)^2}$

- Allowable Tensile Stress

$F_t = 0.60\ Fy$

where

A_f = Area of the compression flange (cm^2)

C_b = $1.75 + 1.05(M_1/M_2) + 0.3(M_1/M_2)^2$, but not more than 2.3, where M_1 is the smaller and M_2 the larger bending moment at the ends of the unbraced length, taken about the strong axis of the member, and where M_1/M_2, the ratio of end moments, is positive when M1 and M2 have the same sign and negative when they are of opposite signs. When the bending moment at any point within an unbraced length is larger than that at both ends of this length, the value of C_b shall be taken as unity.

E = Modulus of elasticity of steel (kg/cm^2)

F_a = Allowable axial compressive stress (kg/cm^2)

F_b	=	Allowable bending stress (kg/cm^2)
F_t	=	Allowable axial tensile stress (kg/cm^2)
Fy	=	Specified minimum yield stress of the type of steel being used (kg/cm^2)
b_f	=	Flange width of rolled beam (cm)
d	=	depth of beam (cm)
l	=	Unbraced length of member (cm)
r	=	radius of gyration (cm)
r_T	=	radius of gyration of a section comprising the compression flange plus 1/3 of the compression web area, taken about an axis in the plane of the web (cm)

9.0 DESIGN OF MEMBER

10.0 CONCLUSION

The building as laid out , analyzed and designed herein are acceptable. All of the members including slabs , beams , columns , pile caps and roof structures have been designed in accordance with governing codes and standards.

Maximum horizontal displacement of the building due to wind load is 2.835 cm. Allowable horizontal displacement is equal to 1800 / 300 = 6.00 cm. Therefore , the horizontal displacement of the building is within allowable limit.

Overall dimensions and details are as shown on the Attachment.

11.0 ATTACHMENT

1) Control building Details Drawings (10 pages)
2) Parameter for Pile Design Figures A , B , C , D , E , F (3 pages)
3) Log of Boring No. BH-1 , BH-2 , BH-3 (3 pages)
4) Analysis model and structural analysis Input / output. (41 pages)

DYNAMIC ENGINEERING CONSULTANTS CO., LTD.

STANDARDIZATION OF DESIGN DRAWINGS

1. DRAWING TITLE BLOCK

The title block of a drawing will contain a few component parts, arranged sequentially. These are explained hereafter.

1.1 Reference Drawings

Above the title block, a list of the reference drawings will be provided. The list will contain the number of the drawings which are related to the present drawing.

1.2 Revisions

Revisions part of the title block will contain several columns as explained below.

The first column will indicate the revision number numerically. The original issue will have zero revision number.

The second column will indicate the date on which the particular revision is made.

The third column will indicate the description of the particular drawing.

The fourth column will contain the signature of the designer who has done the design work of this drawing.

The fifth column will contain the signature of the designer who checked the drawing.

The sixth (last) column will contain the signature of the person who approved the drawing.

All columns in the Revision sub-block will start from the bottom and will proceed upward as the revision continues.

1.3 Project Name

The Project sub-block will contain three lines.

The first line will contain the name of the Project.

The second line will contain the name of the building or structure as the case may be.

The third line will contain the details of the particular drawing.

1.4 Client

This sub-block will contain the name of the Client and their official logo. Name and address of the Client may be written if the client wishes.

1.5 Distribution

This part will show the names in brief of the parties to which the drawing is being distributed.

1.6 Proprietary Right

This sub-block will contain a standard statement indicating the propriety right of the Client.

1.7 Consultant

This sub-block will contain the name address, telephone and fax numbers of the Consultant. In this case the Consultant is Dynamic Engineering Consultants Co., Ltd.

1.8 Job Code

The SEATEC Group has a system of job code. The job codes are basically derived from that system. The details of the job codes are as follows:

First two digits	Last two digits of the year concerned
Third digid	3
Last three digits	Running number of the year

1.9 Purpose

This part will show the purpose for which the drawing is being sent. There are six purposes such as (1) Preliminary, (2) Information, (3) Review, (4) Approval, (5) Construction, (6) As Built. The appropriate purpose will be indicated by ticking in the appropriate place.

1.10 Drawing Number

The drawing number will be according to the drawing numbering system explained in Section 2.

1.11 Sheet Number

This sub-block will indicate the number of the particular sheet and out of the total number of the sheets prepared for the project. This will be written at the final stage when all the drawings are prepared.

1.12 Format

The format for the title block is shown in the next page. The width of the Title block will be 9 cm. The height may be adjusted as per requirement in a specific case.

2. DRAWING NUMBERING SYSTEM

The drawings generally prepared by A Engineering Consultants Co., Ltd. can be categorized discipline-wise which is shown below. The numbering system will contain four parts: (1) Building Code, (2) Discipline Number, (3) Section Number, and (4) Running Number. The system is illustrated hereafter.

☐☐☐	☐☐	☐☐	☐☐☐
Work Code	Discipline Code	Section No.	Runmng No.

Reference Drawings

.....

.....

		Original			
No.	Date	Description	Designed	Checked	Approved

REVISIONS

Logo Name of Client Address of Client	Client Approval Signature: Date:

This Drawing is confidential and is the exclusive property of .....
——————(Client/Owner Name) —————— and is loaned subject to the condition that it is not to be reproduced or used to furnish information for the making of Drawings for prints except as sanctioned in writing by —————— (Client/Owner Name) .....
—————— and shall be returned upon request.

Project Name:

Building / Structure Name :

Drawing Title:

Drawn:	Project Manager:
Designed:	Date:
Checked:	Scale:

Project No. □ □ □ □ □ □

DWG.NO. : □ □ □-□ □-□ □-□ □ □

Sheet ..... Of .....

2.1 Work Code

The Work Code will contain three letters implying the specific building. For example, FAC may be used for factory building, WAR may be used for warehouse etc. For a project, the building codes will be set by the Architect in consultation with the Project Manager. Everyone involved in the project must follow the same codes.

2.2 Discipline Code

The Discipline Code will contain two letters. These are the disciplines to which the specific drawing will relate. The following Codes will be followed:

AR	Architectural
CV	Civil
ST	Structural
EE	Electrical
CM	Communication
NE	Mechanical
DR	Drainage
SN	Sanitary and Environment

2.3 Section Number

Each Discipline will have several sections. These are predetermined. The sections in each Discipline will contain two digits. The Section Numbers will be as shown separately.

2.4 Running Number

The running numbers will appear at the end of the numbering system. This will contain three digits, These numbers will be set by the individual designers.

Example: FAC-ST-02-006. In this example FAC will indicate factory building, ST will indicate Structural Discipline, 02 will indicate section 02 of Structural Discipline (RC Substructure) and 006 will indicate the running number within that section.

2.5 Discipline and Section Details

The standard discipline and the section details are shown hereafter. All drawings will be fitted into these disciplines and sections.

AR Architectural

AR-00	Standard Drawings (also details and notes)
AR-01	Master & Layout Plan
AR-02	Perspective
AR-03	Plan (Floor, Ceiling, Roof)
AR-04	Elevation
AR-05	Section
AR-06	Details (Stair, Door & Window, Toilet, Interior, Finishing)
AR-07	Schedules (Door & Window, Finishing)
AR-08	Interior Design
AR-09	Landscaping
AR-10	Fencing

CV Civil Works

CV-00	Standard Drawings (also General Notes)
CV-01	Earth Work (Site Preparation, Cut & Fill)
CV-02	Road
CV-03	Drainage
CV-04	Bridges
CV-05	Trunnel
CV-06	Railway
CV-07	Airport

	CV-08	Harbour and Marine Work
	CV-09	Dam and Irrigation Structures
ST	**Structural**	
	ST-00	Standard Drawings (also General Notes)
	ST-01	Piling Work
	ST-02	RC Substructure (Pile Cap, Footing & Structure below Ground Floor)
	ST-03	RC Superstructure (Ground Floor and Above Structure)
	ST-04	Steel Substructure (Sheet Piling etc.)
	ST-05	Steel Superstructure
EE	**Electrical**	
	EE-00	Standard Drawings (also general notes)
	EE-01	High Voltage Distribution Line
	EE-02	Low Voltage Distribution Line
	EE-03	High Voltage Switchgear
	EE-04	Low Voltage Switchboard
	EE-05	Street Lighting
	EE-06	Outdoor Lighting
	EE-07	Interior Lighting
	EE-08	Sounding System
	EE-09	Emergency Power Generation
	EE-10	Lightning Protection
	EE-11	Airfield Lighting (Visual aid System)
	EE-11	Control System
	EE-12	Fire Alarmn System
CM	**Communication**	
	CM-00	Standard Drawings (also general notes)
	CM-01	Telephone
	CM-02	Telecommunication

	CM-03	Sound and Public Address System
	CM-04	CCTV
	CM-05	MATV
ME	**Mechanical**	
	ME-00	Standard Drawings (also general notes)
	ME-01	HVAC (Heating, Ventilation, Air Conditioning)
	ME-02	Fire Protection
	ME-03	Steam Generation and Hot Water
	ME-04	Refrigeration
	NE-05	Transport in Building (Conveying System, Elevator, Escalator, Dumb Waiter, Cranes)
	ME-06	Liquid Fuel Storage
	ME-07	Fuel Gas
	ME-08	Compressed Air, Gas
	ME-09	Vacuum Air
DR	**Drainage System**	
	DR-00	Standard Drawings (also general notes)
	DR-01	Layout Plan
	DR-02	Details
SN	**Sanitary and Environment**	
	SN-00	Standard Details
	SN-01	Water Distribution or Water Supply
	SN-02	Water Treatment Plant
	SN-03	Waste Water Collection System
	SN-04	Waste Water Treatment Plant
	SN-05	Plumbing System
	SN-06	Solid Waste Management

SN-07 Incinerator

SN-08 Sanitary Landfill

3. DRAWING SHEET

A specimen of the drawing sheet is attached. The specimen shows the location and the format of the Title block. Also the reference coordinate system to be followed in all design drawings is shown. The exact number of horizontal rows and vertical columns will be decided by the designer concerned depending on the particular drawing requirement.

- **Detailed in the Drawings**

A checking person must check all of details in the drawings such as dots, lines, curves, etc. These components must be in company standard. The weight and size for each symbols should be the same. For example, the lines which represent the foundation must have the same size and weight.

- **Sizes of Drawings**

There are many sizes of drawings such as AO, A1, A2, A3 etc. A checking person has to check the sizes of the drawings whether they are met the contract requirements. Sometimes, there are some errors from the printer machine so the sizes of the drawings are not equal. A checking person must check before sending them to the customers.

- **Number of Copies**

A checking person have to find for the number of copies from the contract. Then, they must check the number of copies which have been printed. The amount of drawings in each copies must also be checked.

- **Specialists' Sign**

Before all of drawings are sent to the client, the specialists who are senior engineers or senior architectures have to sign these drawings. It means that they are responsible for the result from the design in these drawings. A checking person has to check that all of drawings have the specialists' sign.

- **All drawings are matching**

There are relationship among these drawings. One drawing may refer to other three or four drawings. A checking person has to check this relation. A number, name and details of the reference drawings must be matched with the drawing which refers to.

- **Scales of Drawings**

The scales of each picture must be shown under that picture. All of the scales in each drawings must be shown in the title block. A checking person has to check that each scale is matching with its picture. This item is very serious when the drawings are issued to the government office such as Industrial Estate Authority of Thailand to ask for the permission.

G) Technical Check

The company should develop a "Technical Check". This process is to ensure the technical quality of the product. This process should be carried out independently by the other designers who do not actually design. The reason is that it is quite difficult for the designers to find the errors in their own products. The items which have to be checked in this process are as follow :

Standard Code

In order to design the structure or system, there are many standard codes to be followed. These code are developed by differents countries. For structural engineering, ACI code was developed and used in USA., BS code was developed and used in England. Moreover, these codes are different up to the type of the structure. For example, ACI code is for concrete structure. ATSM code is for steel structure. The chief engineers have to check whether the code which the junior engineers have selected are suitable for the structure or not. Furthermore, they have to check the formulas which are selected from the code too. These codes and formulas are demonstrated in the calculation sheets. The senior engineers have to investigate the calculation sheets carefully

Local Rules and Regulations

The rules and regulations for each type of structure and system are different. The chief engineers have to check whether the designers have follow these rules or not. Missing these rules will cause the problems in the process of asking for the construction permission from the government. The examples of these rules are the ratio between the toilet

area and usage area in factories, amount of extinguish equipments per area. Moreover, the area in Thailand is devided into zone such as residental zone, industrial zone, etc. In some area such as residental zone, the construction of the factories are not permited.

Servicability

Besides the strength, the servicability of the structure and system must be considered too. For example, if the size of the beam is so big, the space area may be less than required. Thus, the designer has to solve this problem by changing the shape of this beam.

Economy

Money is one of very important items which the owner concerned. Thus, the chosen types of st

Safety

Safety is very important factor. The chief engineers have to consider this item for both construction phase and operation phase. In construction phase, the construction method must be safe for the workers and other people who work in the site. After the construction is completed, these structure and system must be safe for everyone who work in this factory.

The examples of Quality Check and Technical Check Form are shown in next page.

A ENGINEERING CONSULTANTS CO., LTD.

DRAWING FORMAT

Quality Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Drawing Title Block		
2	Reference Sub-block		
3	Revisions Sub-block		
4	Client Sub-block		
5	Proprietary Right Sub-block		
6	Consultant Sub-block		
7	Project Name		
8	Signature and Scale		
9	Job Code		
10	Drawing Number		
	Work Code		
	Discipline Code		
	Section Number		
	Running Number		
11	Sheet Number		
12	Purpose		
13	Layout and Size		

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

ARCHITECTURAL DESIGN

Quality Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Technical checks done		
2	Standard drawing format followed		
3	Drawing print correct		
4	Drawing size all right		
5	Meets client's requirements		
6	Number of Copies all right		
7	All relevant persons signed		
8	Drawings are matching		
9	Scales are all right		
10	Purpose mentioned		

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

ARCHITECTURAL DESIGN

Technical Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Local rules & regulations followed		
2	Serviceability		
3	Economic consideration		
4	Aesthetic consideration		
5	Constructability		
6	Safety consideration		
7			

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

STRUCTURAL WORKS DESIGN

Quality Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Technical checks done		
2	Engineering calculations in order		
3	Standard drawing format followed		
4	Drawing print correct		
5	Drawing size all right		
6	Meets client's requirements		
7	Number of copies all right		
8	All relevant persons signed		
9	Scales are all right		
10	Purpose mentioned		

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

STRUCTURAL WORKS DESIGN

Technical Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Design criteria followed		
2	Engineering calculations, editing		
3	Structal stability		
2	Serviceability		
3	Economic consideration		
4	Aesthetic consideration		
5	Constructability		
6	Safety consideration		
7			

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

CIVIL WORKS DESIGN

Quality Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Technical checks done		
2	Engineering calculations in order		
3	Standard drawing format followed		
4	Drawing print correct		
5	Drawing size all right		
6	Meets client's requirements		
7	Number of copies all right		
8	All relevant persons signed		
9	Scales are all right		
10	Purpose mentioned		

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

CIVIL WORKS DESIGN

Technical Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Design criteria followed		
2	Engineering calculations, editing		
3	Structal stability		
2	Serviceability		
3	Economic consideration		
4	Aesthetic consideration		
5	Constructability		
6			
7			

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

ELECTRICAL WORKS DESIGN

Quality Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Technical checks done		
2	Engineering calculations in order		
3	Standard drawing format followed		
4	Drawing print correct		
5	Drawing size all right		
6	Meets client's requirements		
7	Number of copies all right		
8	All relevant persons signed		
9	Purpose mentioned		

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

ELECTRICAL WORKS DESIGN

Technical Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Design criteria followed		
2	Codes & regulations followed		
3	Local and standard practices followed		
4	Engineering calculations, editing		
5	Safety consideration		
6	Economic consideration		
7	Materials availability		
8	Repair & maintenance		
9			
10			

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

MECHANICAL WORKS DESIGN

Quality Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Technical checks done		
2	Engineering calculations in order		
3	Standard drawing format followed		
4	Drawing print correct		
5	Drawing size all right		
6	Meets client's requirements		
7	Number of copies all right		
8	All relevant persons signed		
9	Purpose mentioned		

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

MECHANICAL WORKS DESIGN

Technical Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Design criteria followed		
2	Engineering calculations, editing		
3	Comment from client attended		
3	Economic consideration		
4	Ease in handling material, provision & installation		
5	Specification preparation		
6	Bill of quantities		
7			

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

SANITARY AND ENVIRONMENTAL WORKS DESIGN

Quality Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Technical checks done		
2	Engineering calculations in order		
3	Standard drawing format followed		
4	Drawing print correct		
5	Drawing size all right		
6	Meets client's requirements		
7	Number of copies all right		
8	All relevant persons signed		
9	Purpose mentioned		

Recommendation:

A ENGINEERING CONSULTANTS CO., LTD.

SANITARY AND ENVIRONMENTAL WORKS DESIGN

Technical Checks

Project (No./Name):
Designed by:
Manual Referecne:

Drawing No.:
Quality Check by:
Date:

No.	Item for Check	Comment	Signature
1	Design criteria followed		
2	Engineering calculations, editing		
3	Structural stability		
2	Serviceability		
3	Economic consideration		
4	Aesthetic consideration		
5	Constructability		
6			
7			

Recommendation:

K) Submittal

After the drawings are checked technically and qualitatively, they will be transmitted to the client for his approval.

L) Revision

After the drawings and calculation sheets are sumitted to the Client, he will check all drawings and calculation sheets and may ask for revision. The drawings will be revised accordingly.

M) Final Submittal

The final submittal will be through the standard transmittal form. Before sending the drawing to the Client or to the Site, it will be recorded in the file.

N) Computer Network

Computer Technology should be applied in design work. DEC should set LAN system. By LAN, designers can access the drawings and data they want by themselves. For example, the structural engineer can see the piping drawings from mechanical engineer to use as data for design level of beam.

4.5.2 CONSTRUCTION SUPERVISION WORKS

I) Scope of Works

The works under supervision is to provide professional and technical manpower the site in order to control the quality of the works which are constructed by one or more contractors. Type, number and duration of manpower to a project site depend on the contract requirements. The requirements are set based on the contract. The main tool of the construction supervision is the contract between the client and the contractor. The consultant works on the behalf of the client.

II) Supervision Works

After the detailed design works are completed, an organization chart for construction supervision is prepared. The amount and type of professional and other technical manpower depend on the complexity of the works and as per contract requirements. Typically, the organization is set by a project manager. Responsibilities of the project personnel related and connected to supervising work are as follow:

Project Manager

Responsibilities:

1) The decision making person of the project on the behalf of A.
2) Aministrative matters of the project staff of A.
3) Arrange and conduct the kick-off meeting.
4) See that the supervision works are proceeding according to the work schedule.
5) Coordinate with the Client or his representative.
6) Coordinate with the head office.
7) Prepare the progress report and transmit to the client.

Site Manager

1) The decision making person in the site on the behalf of A.
2) Administrative matters of the project staff in site.
3) Conduct the inspection and testing for construction supervision works.
4) Coordinate with the contractors.
5) Arrange progress meeting.
6) Provide data for making progress report to project manager.
7) Arrange to solve the problems arising during the progress of supervision work.
8) Manage all the changes and additional works.
9) Coordinate the supervision works of all departments in site.

Site Engineer

1) Take full responsibilities of the construction supervision works.
2) Report the progress of work and any data to the site manager.
3) Obtain data and distribute to the concerned inspectors.
4) Study the detail drawings and control the construction of contractors to meet the drawings.
5) Provide some technical advise to the inspectors.

Inspectors.

1) Inspect the works of contractors.
2) Report the progress and problems of works to site engineers.

Before the beginning of construction supervision work, the **kick off meeting** should be held. This meeting is attended by the representative of the client, the contractors, the project manager form A and other professionals assigned for the project. In this meeting, the scopes of works for each company are discussed. The responsibilities of the supervisory staff of A are explained. The staff of A have no direct control or responsibility for the quality of the works. The A staff's responsibility is to watch and supervise the construction and completion of the works, and to be satisfied that the works are executed by the contractor according to the contract.

The project manager and other suitably qualified members of the design team, should **visit the site** as aften as considered necessary by the project manager or project advisor to fulfil the requirements of the agreement with the client. Such visits will normally concide with periodic coordination and progress meeting held on site, which A is also mormally required to attend or required to arrange if A is the Lead Consultant.

The progress meeting must be held once a week. It is to monitor the progress of the work. These meeting are usually attended by representative of the client, project manager of the contractor, project manager of A and others as necessary. The quality of the works being done by the contractor is an important item discussed in the progress meeting.

Each inspector of each department reports the deficiency to the site engineer of each department. The site engineer checks and tries to resolve with the contractor. If this is not enough, the site manager is involved. Minutes of the progress meetings are recorded and distributed to the concerned people including the client.

Measurement

The site engineers and site staff should measure the work done on site. Although the actual method of carrying out this duty on a daily basis is a matter for the site manager, the project manager should ensure that the site engineers are aware of the basic requirments and that measurement should be carried out as the work progress in a methodical manner. These basic requirements should include the following.

- The site engineer must check and agree that the contractor's survey of the site is correct before any earthmoving is started. The site engineer must record all information which might be needed from the survey for the purposes of measurement. In checking the contractor's survey, the site engineers should be satisfied as to the accuracy of the measurement equipment supplied by the contractor.

- The site engineers must examine and record particulars of labour, plant and materials employed on daywork so that time-record sheets can be approved from factual data. The site engineers must ensure that time-record sheets in duplicate are furnished to him daily by the contractor. After considering them, the site engineers must sign them, retain one copy and return one copy to the contractor.

- Where a variation of price clause is contained in the contract, the site engineers must record classes and hours of labour employed and materials delivered. The site manager must obtain evidence from the contractor to support increased prices of materials and to show that the most favourable method of procurement is being used.

4.5.3 COST CONTROL

The cost control processes must begin with the first visibility to a project. They must continue through the preperation of the estimate, on through the development of the project strategy, and through the full development of the plan and the selection of the team member who will be responsible for producing the project.

The Project Strategy of Cost Control

The estimation is one of cost control tool. The estimating process is essential. In order to make the effective estimating process, the initial project strategy is required as a prerequisite to the actual estimating. The initial project strategy will affect significant factors relating to the cost of the project. For example, a major component of cost is the general requirements cost, which is more or less a direct function of the duration of the project. It is not possible to estimate accurately the time related general requirements cost without first clearly establishing.

1. An expected duration of the project
2. The intensity of project management and supervisory effort which will be required in order to produce the project in view of its difficulties and complexities.

Along with construction strategy, the interrelationships of the activities required to produce the project are also significant in having a direct effect on the overall duration of the project as well.

The Engineering Consultant Company's Role in Cost Control

As an engineering consultant company, company A. has to perform the cost control procedures in each phase as follow:

1. Pre – Design Phase

    1.1 Make Project Feasibility Study and Preliminary Project Budget.

2. Preliminary Design Phase

    2.1 Consider construction site and related environments.

    2.2 Make the Project Cost Planning for every part of the project.

    2.3 Make the Alternative System Analysis.

3. Design Development and Contract Document Prepaeration

    3.1 Make the Cost Check for every step of works.

    3.2 Make the suitable Master Plan.

    3.3 Advise the owner about the purchasing, surveying, soil testing, etc.

4. Term of Requirement (TOR) document Preperation

    4.1 Prepare the suitable conditions for bidding, duration of construction.

    4.2 Prepare the Bill of Quantities (BOQ)

5. Bidding Phase

    5.1 Select the most suitable contractor.

6. Construction Phase

    6.1 Check the progress report, monthly report and other related reports from the contractors.

    6.2 Make the Cost Check for every step of its own work.

The Cost Control Monitoring and Review Cycle

There is a repetitive cycle relating to effective cost control while a project is in progress.

- Strategy or expected performance
- Implementation
- Actual cost
- Comparison to planned
- Evaluation of Performance data
- Corrective action (new strategy)
- Reimplementation

The following documents are the example of cost control forms. These forms are useful to engineering consultant company to control its own project cost in order that it does not exceed the estimated one. The first form is the "Cost Check for Design Work". By this form, the company can control the man-hour and material for producing each drawing. The second one is "Summary of Staff". This form is used in construction site to control man hour for the supervision work in each month. The last one is the "S-Curve" in construcvtion progress. It is helpful to control time in construction work. Time control is essential to cost control because time is a direct function of cost in construction site.

PROJECT NAME _____ DATE _____

PROJECT NUMBER _____ PROJECT MANAGER _____

DRAWING NUMBER	DRAWING NAME	TIME		TIME		AMOUNT OF PRINTING			REMAKRS
		DESIGNER	DRAUGHTSMAN	DESIGNER	DRAUGHTSMAN	AO	A1	A3	

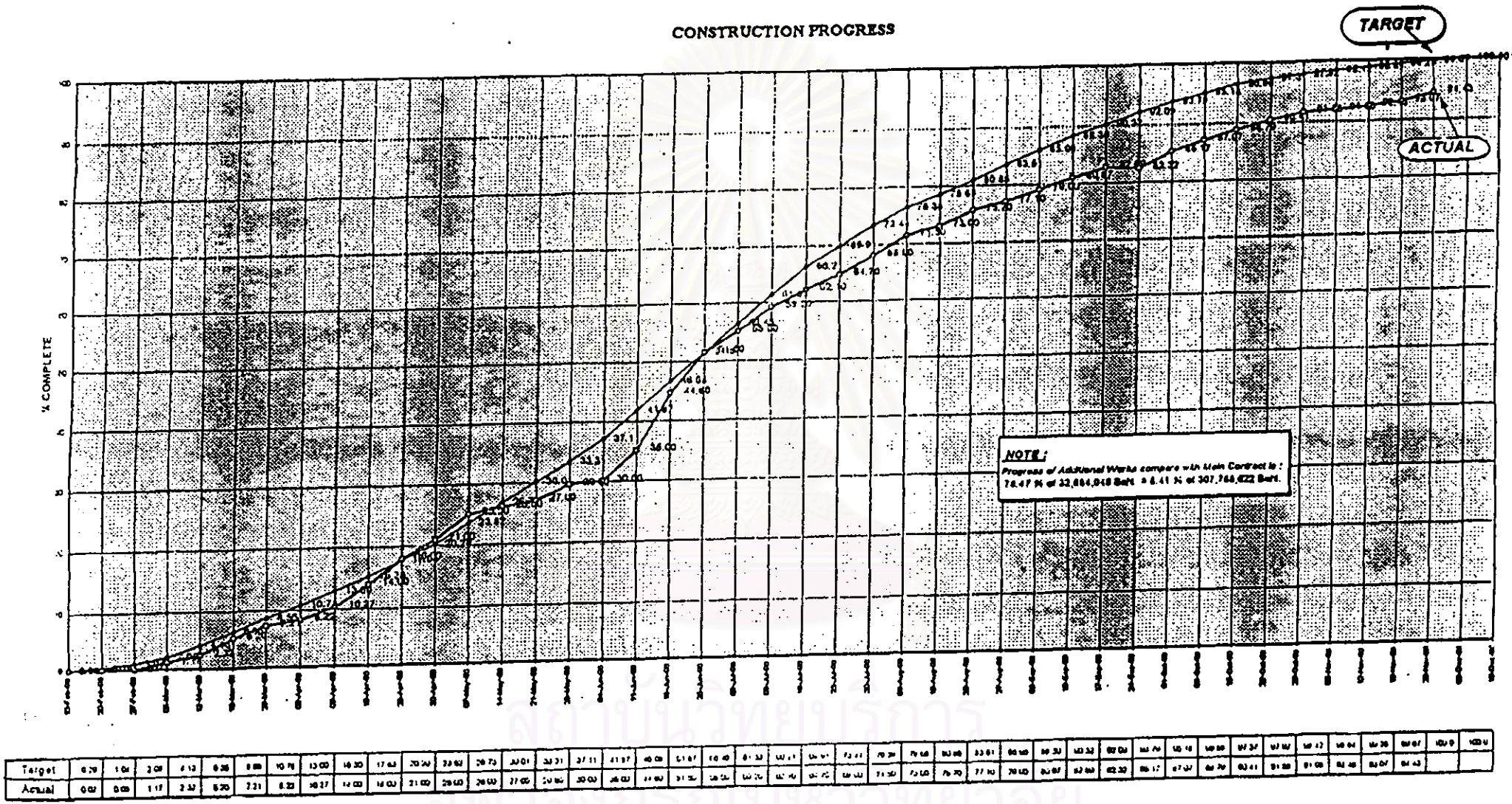
COST CHECK FOR DESIGN WORK

SUMMARY OF STAFF

PROJECT : **CONTRACTO :**

OWNER : **MONTH :**

ITEM	DESCRIPTION	Fri 1	Sat 2	Sun 3	Mon 4	Tue 5	Wed 6	Thu 7	Fri 8	Sat 9	Sun 10	Mon 11	Tue 12	Wed 13	Thu 14	Fri 15	Sat 16	Sun 17	Mon 18	Tue 19	Wed 20	Thu 21	Fri 22	Sat 23	Sun 24	Mon 25	Tue 26	Wed 27	Thu 28	Fri 29	Sat 30
1.	PROJECT MANAGER																														
2.	SITE ENGINEER																														
3.	WORK SUPERVISOR																														
4.	DRAUGHTSMAN																														
5.	FOREMAN																														
6.	M & E ENGINEER																														
7.	SECRETARY, CLEARK																														
8.	CASHIER																														
9.	SITE ADMIN CLERK																														
10.	SAFETY																														
11.	COMPUTER OPERATOR																														
12.	SURVEYOR																														
14.																															
15.																															
16.																															
17.																															
18.																															
19.																															
20.																															
	TOTAL																														



S-CURVE for construction progress

4.6 DIFFERENCES BETWEEN EXISTING SYSTEM AND DEVELOPED SYSTEM

4.6.1 PROJECT ORGANIZATION

In developed system, two new positions are established to help the project manager. They are project advisor and project coordinator. In the existing system, project manager had to take the responsibilities to manage the project and coordinate with people from both external and internal the company. He has too much responsibilities. The project advisor will help him by giving some recommendations about the project. For the project coordinator, he will take the responsibility of internal coordination. Consequently, the new project organization can solve the problems of too much responsibilities of project manager.

The supported team are devided into two groups in the developed system. Thus, they can work effectively. Their skills will be improved because they will do the related work for many projects. They can pay all their attention in the same types of works. Consequently, they will develop their process by finding new method or applying new computer technology

4.6.2 DESIGN WORK SCOPE AND DATA AQUISTITION

In developed system, all concerned people will understand the over all project by Design Work Scope. They will know the general scope, general characteristics of facilities, volume of construction work, basis of design, scope of design/documents to be produced and the highlight of the project. Thus, all designers can do their works to meet the objectives of the project effectively. This will solve the problems that the designers do not understand the overall the projects.

The Data Aquisition is useful for the chief designers and designers to examine whether the relevant information are available or not. Thus, they can get all essential information before starting design works. Otherwise, they have to stop their work to wait for some information.

4.6.3 FORMAL KICK-OFF MEETING

In existing system, the kick-off meeting among the client, project manager and chief designers from all departments was not held for every projects. For some projects, only the project manager and structural chief designers joined the meeting with the client.

By kick-off meeting in developed system, the scope of works will be clear to every concerned departments. Every chief designers can discuss with the client and ask for more essential information.

4.6.4 INTERNAL MEETING

In existing system, every departments began their work after they got enough information to design. Some chief designers discussed about their works to each other. There were not formal meeting among concerned departments.

Every chief designers have to join the internal meeting in developed system. They will discuss about the scope and characteristics of their works. The conclusions of works for each departments are made before starting the design works. Consequently, the problems of conflicts between each departments will be reduced. The cooperation among the design group is improved.

4.6.5 STANDARD DESIGN CRITERIA BY CHIEF DESIGNERS

In existing system, the design criteria was made by junior designers after they had received information from their chief. These design criteria might not meet the objectives of the project. It caused a big problems because all design works were done according to this design criteria. If this design criteria must be changed, these design works must be changed too.

In developed system, the design criterias will be made by the chief designer. Thus, they will meet the objectives of the project and do not contrast to one another. Moreover, they will be in standard forms of company so it is easy to understand and investigate.

4.6.6. STANDARD OF DRAWINGS AND CALCULATION SHEETS

In the existing system, each designer developed his own standard of drawings and calculation sheets. Thus, there were many styles of drawings and calculation sheets issued to the client. It caused some problems to checking person and clients to study them. The contractors always blame A that the drawings are not in the same standard.

In developed system, all drawings and calculation sheets will be in the same standards. Although there are many groups of designers, the production from every groups are in the same styles. Consequently, it is easy to understand these drawings and calculation sheets.

4.6.7. CONCEPTUAL DESIGN BY CHIEF DESIGNERS

There were not any concept designs in the existing system. Every junior designers began their preliminary design after they had received the information from their chiefs. There might be some conflictions among each designer.

In developed system, the chief designers will make the conceptual design by themselves. So, junior designers can do their design works according to the conceptual design. The conflictions among designers and number of corrections will be reduced.

4.6.8. TECHINCAL CHECK AND QUALITY CHECK

In developed system, there are formal checking system. Chief designers have to perform the technical check and quality check every week. At the end of the week, all the works which complete in that week must be checked. In the existing system, the informal checking system was performed after all of works had been completed. It would take quite a long time and money if some drawings were corrected.

By this new checking system, the quality of drawings and quality of design will be improved. If the works are not completed in time, the project manager will know the causes because every checking steps are written down in documents.

4.6.9 DIRECT COMMUNICATION BETWEEN DESIGNERS AND SUPERVISING PERSONS

If there are some problems about the drawings or not enough information for construction works, the supervising persons will ask for the answers directly from the designers. In the existing system, they had to contact with the project manager. It took quite a long time to get the answer.

This direct communication will reduce time to solve the problems from drawings. All problems are solved in time with less impacts on construction works.

4.6.10 CLEAR CONCLUSION FOR RESPONSIBILITIES IN SUPERVISING WORKS

In the existing system, the responsibilites for each company in construction site caused some conflictions. It was not easy to find someone to be responsible for the problems which had been occurred. There were not any clear conclusions of responsibilites for each company.

In the developed system, there will be the kick-off meeting among owner, contractors and consultants before starting works. The scope of works and responsibilities of each company are discussed to make a clear conclusion. Thus, the conflictions among these companies during construction supervision works can be reduced.

4.6.11 CERTAIN DESIGN PROCEDURE

In the existing system, there was not certain design procedure. Everyone performed design work as they were used to. By the certain work procedure in developed system, everyone will know which step they are in design process, what they should do next and who they should contact with.

4.7 THE ADVANTAGES OF DEVELOPED SYSTEM

By the developed system, A will improve the quality of its products, and perform its business effectively. The advantages of developed system are classified as follow:

4.7.1 HUMAN-RESOURCES

- The project manager will perform his work effectively. He will not have so much responsibilites like in existing system. The project advisor and project coordinator will take some of his responsibilities.

- The supported teams will improve their skill for specific types of work. Thus, they will perform their work efficiently

4.7.2 TIME

- Time for correcting drawings will be reduced. The drawings will be checked every week so the unsuitable drawings will immediately be corrected before they were used as reference for making other drawings. Thus, the number of corrected drawings and time for correcting will be reduced.

- Time for junior designers to perform the design work will be reduced. They will receive the design criteria and conceptual design from their chief. Thus, they can start their design work without any hestitation about the concept of design.

- Time for CAD operators to make the drawings will be reduced. All of their works have relationship in themselves. They can find some data by themselves without asking from designers. Moreover, their skill will be improved.

- Time for revising drawings will be reduced. The contractors and site engineers can contact with designers directly. Drawing revising steps are reduced.

- Time for solving problems in construction site will be reduced. The site engineers will discussed with designers directly.

- Wasted time for solving some problems in design process and supervising process such as problems between structure engineer and architecture, problems between A and contractor will be reduced. These problems will be eliminated in developed system.

4.7.3 MONEY

- Cost for correcting drawings from checking process will be reduced. The number of drawings to be corrected will be reduced because there are checking system every week during design process.

- Cost for correcting drawings from conflictions between departments will be reduced. There are internal meeting among all departments so the products from all departments should perform in the same direction.

- Cost for revising drawings will be reduced. The steps in revising drawings are reduced so the costs in those steps are eliminated.

4.7.4. QUALITY

- Quality of drawings will be improved. The errors in drawings will be reduced because there are both technical check and quality check system. Moreover, all drawings are in the same standard so they are easy to be checked and studied.

- Quality of calculation sheets will be improved. There are standard design criteria as a basis for everyone to study these calculations. These calculation sheets are in the same standard so it is easy to be studied and checked.

- Quality of work procedure will be improved. There are the certain flow chart for overall work procedure, preliminary and detailed design process. Everyone will know where they are and what they should do next in the work process. Thus, all the works should flow efficienctly.

4.8 METHODS FOR ESTIMATING THE COST OF DESIGN AND SUPERVISION

Nowadays, the methods to estimate the cost of design and supervision of A can be classified into two methods. They are Conceptual Estimating Method and Parametric Estimating Method. In other companies, there may be other methods used to estimate the

total design and supervision cost. The most suitable method for each company is usually depending on the level of information and capability of each engineering consultant company.

4.8.1 CONCEPTUAL METHOD

For Conceptual Estimating Method, A provide a budgeting cost figure of the total design and supervision works to the client. The steps of this method is as follow.

I. Estimating total design effort

To estimate the total design effort, A have to

i) estimate the number of key persons such as senior architects, senior engineers.

ii) forecast the time span of each person that is required to finish the design work.

iii) calculate the total man-hours/months of each profession.

II. Assigning the basic salary to each professions

The cost of the total design effort for each profession is calculated by using the basic salary of each profession multipled by their total design effort (man-hours/months), required to design the project.

III. Estimating for the overhead costs and social charge cost of each profession

Normally, the accounting department of B Group has calculated the social charge costs and overhead costs as percentages of basic salary. The breakdown of social charge costs and overhead costs in 1998 are shown in Figure 4.14 and Figure 4.15.

The breakdown of Social Charges of B Co., Ltd.

(as end of 1998)

		% of basic salary (B.)
1.	Sick leave	8.20
2.	Personal leave	4.10
3.	Paid vacation allowance	2.20
4.	Public holidays	3.60
5.	Social securities/insurances	2.06
6.	Severance pay allowances	5.00
7.	Retirement benefits	5.00
8.	Living allowances	8.18
9.	Incentive allowances	2.11
	Total 40.45	
	Amount Charged **35.00**	

Figure 4.14 The breakdown of social charges of B Co., Ltd.

The breakdown of Overhead Costs of B Co., Ltd. (as end of 1998)

		% of basic salary (B.)
1.	Indirect salaries/wages (management and administrative staff, non productive staff. etc.)	57.17
2.	Office rental and utilities	13.39
3.	Depreciation of office equipment and furnitures	17.46
4.	Office maintenance	0.33
5.	Transportation and communication expenses	10.27
6.	Office supplies and stationaries	3.15
7.	Photocopying and printing expenses	8.56
8.	Computer expenses	0.61
9.	Bank charges and interest	79.10
10.	Entertainment	2.11
11.	Legel and auditing fees	3.55
12.	Public relations and advertising	7.82
13.	Staff training and development expenses	0.73
14.	Miscellaneous	14.37
	Total 218.62	
	Amount Charged 60.00	

Figure 4.15 The breakdown of overhead costs of B Co., Ltd.

IV. Assigning the profit charged to the owner

Generally, the profit charged to the owner of A is 10% of the summary cost. In this step, the summation of basic salary, overhead costs and social charge costs is multipled by the percentage of profit charge.

V. Adding tax to the cost of design and supervision

After A estimates the total cost of design and supervision, tax cost will be added to this cost as a percentage of the total cost of design and supervision.

4.8.2 PARAMETRIC ESTIMATING METHODS

In this method, the cost of design and supervision is estimated from percentage of the construction cost. This method is only used for some project such as small apartment, resident, house, etc.

The percentage is determined by the managing director of A. He has number for each project in his mind. Nevertheless, the relation between cost of design and cost of construction in Thailand is shown in followed table.

Table 4.3 The percentage charged to the construction cost to estimate the cost of design for each type of project and value of construction cost.

Type of Project	Less than 10 BM	10 MB to 30 MB	30 MB to 50 MB	50 MB to 100 MB	100 MB to 200 MB	200 MB to 500 MB
1	8.50	6.75	5.75	5.50	4.75	4.25
2	7.50	6.00	5.25	5.00	4.50	4.00
3	6.50	5.50	4.75	4.50	4.25	3.75
4	5.50	4.75	4.50	4.25	4.00	3.50
5	4.50	4.25	4.00	3.75	3.50	3.25

Source : Sa – la - pan – pun – ha magazine May 1996

*Type 1 = Museum, Temple or Monument

2 = Residental construction

3 = Hospital, Hotel, Theater, University, Condominium or Sport Stadium

4 = Office building, Department store, Dormitory or school

5 = Warehouse, Factory, or Parking Terminal

The activities of design and supervision works are not considered in these two methods. The results from these method cannot be effectively used as a baseplan in project control and management. The manager will not suitably allocate the amount of resources in order to fit to the actual requirements of the company.

In order to determine the design and supervision cost of the developed system, the activities of work procedure and all concerned persons must be considered because the system is newly developed one. There are not any database to be compared in estimating cost. This developed estimating method is called **"Activity breakdown estimating method"**.

4.8.3 ACTIVITY BREAKDOWN ESTIMATING METHOD

When DEC use the activity estimating method to estimate the cost of the design, it should consider all the expenses in detail. The steps to estimate the cost of design are similar to the conceptual estimating method, but A must perform more details for estimating the cost of design.

The procedures of the activity estimating method can be outlined roughly as follows:

i) Make the purposed schedule for all works.

ii) For the cost of total design effort, A has to consider all the persons who are involved in the project.

iii) Reimbursable cost (4.8.3.6 Reimbursable cost) is estimated.

iv) DEC estimates the amount of profit that will be charged for the project.

v) Tax cost is added to the summary cost.

In order to use the activity estimating method, A has to estimate many components such as Billing rate, Basic salary, Social charge cost, Overhead cost, Fee charge, Reimbursable cost, Tax cost and Contigencies. Each component is discussed as follow:

4.8.3.1 Billing Rate

The billing rate is the service cost per unit of the persons who are required to design the project. The billing rate varies to the basic salary of each employee (see 4.8.3.2 Basic salary), social charge cost (see 4.8.3.3 Social charge cost), overhead cost (see 4.8.3.4 Overhead cost), and Fee (see 4.8.3.5 Fee charge).

Billing rate = Basic salary + Social charge cost + Overhead cost + Fee

Salary multiplier or Charge rate = Billing rate / Basic salary

Mon-hour = Man-month / 176

*average working days in a month are 22 days and average working hours in a day are 8 hours.

4.8.3.2 Basic salary

Basic salary is the money that A has to pay to their employees in each month. Related to estimating the design cost, employees of are classified into three groups.

Key staff : architects, engineers, sanitary engineers, mechanical engineer, estimating engineer, etc.

Technical supporting staff : secretary, technician, CAD operators (draftsman), engineer-assistant, typist, drivers, etc.

Administrative staff : engineers or persons who control the project.

Basic salary of each profession depends on qualifications and experience of each employee. Normally, the rate of basic salary of consultant companies in Thailand is shown in table.

Table 4.4 Basic salary rate of each profession

Position	Level	Qualification	E. qiv. Experience* (year)	Basic Salary (Baht per month)
Project Principal	C10	Bachelor degree or higher	-	158,000 or over
	C9	" - "	23 or over	127,900 – 158,000
	C8	" - "	21 - 23	122,800 – 127,900
Key Staff	C7	" - "	18 - 20	119,000 – 122,800
	C6	" - "	15 - 17	110,000 – 119,000
	C5	" - "	12 - 14	97,100 – 110,00
	C4	" - "	9 - 11	90,900 - 97,100
	C3	" - "	6 - 8	73,000 – 90,900
Technician Support Staff	C2	" - "	3 - 5	47,400 – 73,000
	C1	Bachelor Degree	0 - 2	22,000 – 47,400

Source : The conference paper of Thailand engineering association

* Equivalent Experience = Number of years after receiving Bachelor's Degree

= A (Years), with Bachelor's Degree Only

= A + 1 (Years), with Post Graduate Diploma

= A + 2 (Years), with Master's Degree

= A + 3 (Years), with Dectorate Degree

After the economic crisis, these salaries are reduced about 20%

For the basic salary of DEC see table 4.9

4.8.3.3 Social charge cost

Social charge cost is the expenses that A has to be responsible to their employees following to the public regulations. The examples of social charge costs are special auxiliary allowance of bonus money, compensation money, salary of the employee who stops work to take sick leave to be on business leave to take rest leave others.

Social charge cost is usually calculated as a percentage of the basic salary of the employee. The details to calculate the cost of social charges are shown in the table.

Table 4.5 The procedures to calculate the social charge cost

Items		% of basic salary
1. To take sick leave	30/247	12.15
2. To be on business leave (6) or to	18/247	7.29
Take a rest leave (12)		
3. Bonus money	1/12	8.33
4. Contractual money		0.50
5. Others (Services charges, Illness Compensation, Life Insurance cost		5.00
		33.27

Source : The conference paper of Thailand engineering association

* The working day except weekends holidays and national holidays.

Working day = 365 – 104 – 14 = 247 days in a year

However, in each year, there are engineers who retire from companies. It is the responsibility of the companies to compensate the retired engineers. Therefore, some consultant companies add this compensation cost for retired engineers into the social charge cost. The procedures to estimate the compensate money are shown in table.

Table 4.6 The procedures to estimate the compensate money to the retired engineers

Items		% of basic salary
Working days in the company greater than 120 days but less than 1 year	30 (d*) / 120 (d)	25.00
Working days in the company greater (m) than 1 year but less than 3 year	3 (m**) / 12	25.00
Working days in the company greater than 3 years	6 (m**) / 36 (m)	16.67
The average compensation cost		**22.22**
Total social charge cost		**55.49**

Source : The conference paper of Thailand engineering association

* d = days

** m = months

Therefore, some consultant companies charge social charge costs as 55% of the basic salary. However, government set of social charge rate that should be added to the cost of design equal to 35% of the total basic salary.

For A, the social charge rate is 35% of total basic salary as show in Figure 4.14. This figure is based on the data at the end of 1998.

4.8.3.4 Overhead cost

Overhead costs are the office expenses, or the expenses that cannot be defined exactly to a project. Overhead costs for cost of design can be listed as follows:

i) expense for the management engineer or management department
   a) Salary
   b) Overtime working charge
   c) Daily allowance
   d) Bonus money

ii) Office expenses
   a) Office rent
   b) Public utility expenses (Water and Electricity)
   c) Depreciation of furniture and office equipment
   d) Photocopy and stationery costs
   e) Office maintenance costs
   f) Office insurance costs

iii) Office vehicles and transportation costs
   a) Vehicle depreciation
   b) Oil and gasoline costs
   c) Maintenance costs
   d) Insurance costs

iv) Services costs for lawyers and auditors
   a) Vehicle depreciation

v) Office equipment costs

a) Computer depreciation

b) Laboratory depreciation

c) Waste of equipment or materials

vi) Document costs

a) Standard or code documents

b) Referecne documents, books, or joumals

vii) Research and development costs

a) Personal development costs

b) New Equipment, materials, or technology to be implemented in the firm

viii) Telecommunication costs

a) Post, Telephone, Fax machine, or Teleprinter

ix) Tax

a) Building tax

b) Land tax

c) Business tax

x) Preparation costs to make presentation

Similar to the social charge costs, overhead costs are normally calculated as a percentage of the basic salary of the employee. However, overhead cost for each company is different. It varies for number of the employees in the company, size of the company, and the amount of work in a year.

For these overhead cost items, A cannot estimate exactly the cost of the items or even define a project that the overhead cost items belong to. Then, it is very hard for A to make accurate overhead cost estimating for each project. As a result, A still cannot define exactly what are the most important factors those should be considered when they estimate

the overhead costs. In order to study these items, the questionnaires were used for getting data from other companies

Table 4.7 The number of consultant companies interested in each factor which can affect to the overhead costs of design firms

Factors affecting to overhead cost	**Number of design firms***	Percentage
Size of company	15	50.00
Number of employee in company	12	40.00
Inflation	14	46.67
Historical data in last year	20	66.67
Total income in each	9	30.00
Number of existing works in company	20	66.37

* Twenty nine consultant companies responded to the question

From table 4.7 each factor seems to have a significance to the consultant companies when they estimate the overhead cost. However there are four factors, historical data, the number of existing works in the company, size of the company, and the inflation rate, that more than 50% of the consultant companies consider them as important factors that they should be interested during estimating the cost of design.

Furthermore, consultant companies thought the scope of the project, such as size, complexity, type of project, or design duration are other important factors. The consultant companies have to use these factors to estimate the design costs in order to improve estimating ccuracy.

For DEC, the overhead cost is 60% of basic salary. This figure is based on the data in the end of 1998. The details of overhead cost of A is shown in Figure 4.15.

4.8.3.5 Fee charge

The fee charge or profit is the revenue that the A should deserve from the investment and the management in their business. Normally, allowable profit is calculated as a percentage of the total sum of the basic salary, social charge cost, and overhead cost.

Following the public regulations, consultant companies should receive the profit not less than 10% of the total sum of direct cost, social charge cost, and overhead cost.

Table 4.8 The number of consultant companies interested in each factors that can affect to the profit charge of the consultant companies

Factors affecting to overhead cost	**Number of design firms***	Percentage
Interest Rate	11	36.67
Inflation rate	15	50.00
Market Status	24	80.00
Number of existing work in the company	13	43.33
Project construction cost	12	40.00
Number of competitors	20	66.67

* Thirty consultant companies responded to the question

From table 4.8 The most important factors for consultant companies while they determine the profit charge in each project is:

i) market status : when the market situation is good, there is much design work available in the market and the consultant companies have the chance to ask for more profit rate.

ii) Number of competitors : if the consultant companies need to get the project, less profit rate will be charged to the project while there are more competitors in bidding.

About 80% and 67% of the consultant companies realized market situation and number of competitors are important factors respectively when they determine the profit rate that will be charged to the project.

For the other factors, inflation, number of existing works in the firm, project construction cost, and interest rate, consultant companies thought that it can affect to the cost of design. However, it has less significance to the consultant companies. Because, in a real situation, consultant companies believe that the profit rate seems to be limited by market status and the number of competitors in the bidding. Therefore, less than 50% of the consultant companies believe that they have to consider inflation, number of existing works in the firm, project construction cost, and interest rate when they estimate the cost of design.

4.8.3.6 Reimbursable Cost

Reimbursable costs are the expenses that occur from services. Reimbursable cost consist of :

4.8.3.6.1 Field Expenses

The components of field expense can be separated as follows :

i) Miscellaneous travel expenses such as the cost of passports, visas, travel permits, train fairs, etc.

ii) Air fares (for the foreign engineers) : in practice only economy class rates are allowed in the cost of design. For the persons who bring their families the cost of air fares for not more than two persons who are less than 18 years old can be added to the cost of design and persons who follow have to stay in Thailand not less than six months.

iii) Housing or Accommodation Costs : only 20,000 to 30,000 Baht per month can be charged. For foreigners, if they stay in the country shorter than six months, the allowable cost is 20,000 to 30,000 Baht per month. 20,000 to 25,000 Baht per month can be charged if they stay longer than six months and if they stay not longer than 15 days, the maximum cost can be added to the design cost is 1,200 Baht per day. For Thai, in situation

that they had to work in local province, not more than 600 Baht a day can be charged for engineers, 300 to 400 Baht a day for technicians, and 100 to 200 Baht per day for drivers.

iv) Vehicle cost is the cost of oil, gasoline, and maintenance of vehicles. They can add 15,000 to 20,000 Baht per month for the cost of vehicles.

4.8.3.6.2 Office Expenses

i) Cost of communications, such as the telephone, post, etc. The cost of communication is usually charged as a single sum of money in each month. Consultant companies can charge about 3,000 to 6,000 Baht per month.

ii) Cost of miscellaneous materials is normally estimated as a single sum of money in each month. About 5,000 to 8,000 Baht per month is allowed.

iii) Computer and Equipment Cost can be estimated as the same as the cost of communication and cost of miscellaneous materials. About 3,000 to 5,000 Baht per month is allowed.

4.8.3.6.3 Report and Document Cost

The cost of documents or progress reports, 1,500 Baht for an interim report, and 3,000 to 4,000 Baht for a draft or final report.

4.8.3.6.4 Other Expenses

An example of other expenses is the cost of training programs. If a training program is required before starting a design project the consultant companies can negotiate with the owner about the costs that will be included in the design cost.

Reimbursable costs are usually estimated based on the experience of the engineer and the historical data from past similar projects. If the design firms have no good historical data or unskilled persons to estimate the costs of design they can easily lose money in on the project.

4.8.3.7 Tax Costs

There are many types of tax costs which can be classified as follows:

i) 3% Business tax,

ii) 0.3% Municipal tax,

iii) 0.1% Stamp and duties,

iv) 5% Income tax, and

v) 20% remittance tax (if any profit is taken out of the country)

4.8.3.8 Contingencies

The advanced payment that owner must give to the design firm when agreeing on a contract. In general, the owner's payment is separated into four parts.

i) 20% of the design fee is paid to the consultant companies in advance when the consultant companies and owner make an agreement in the contract.

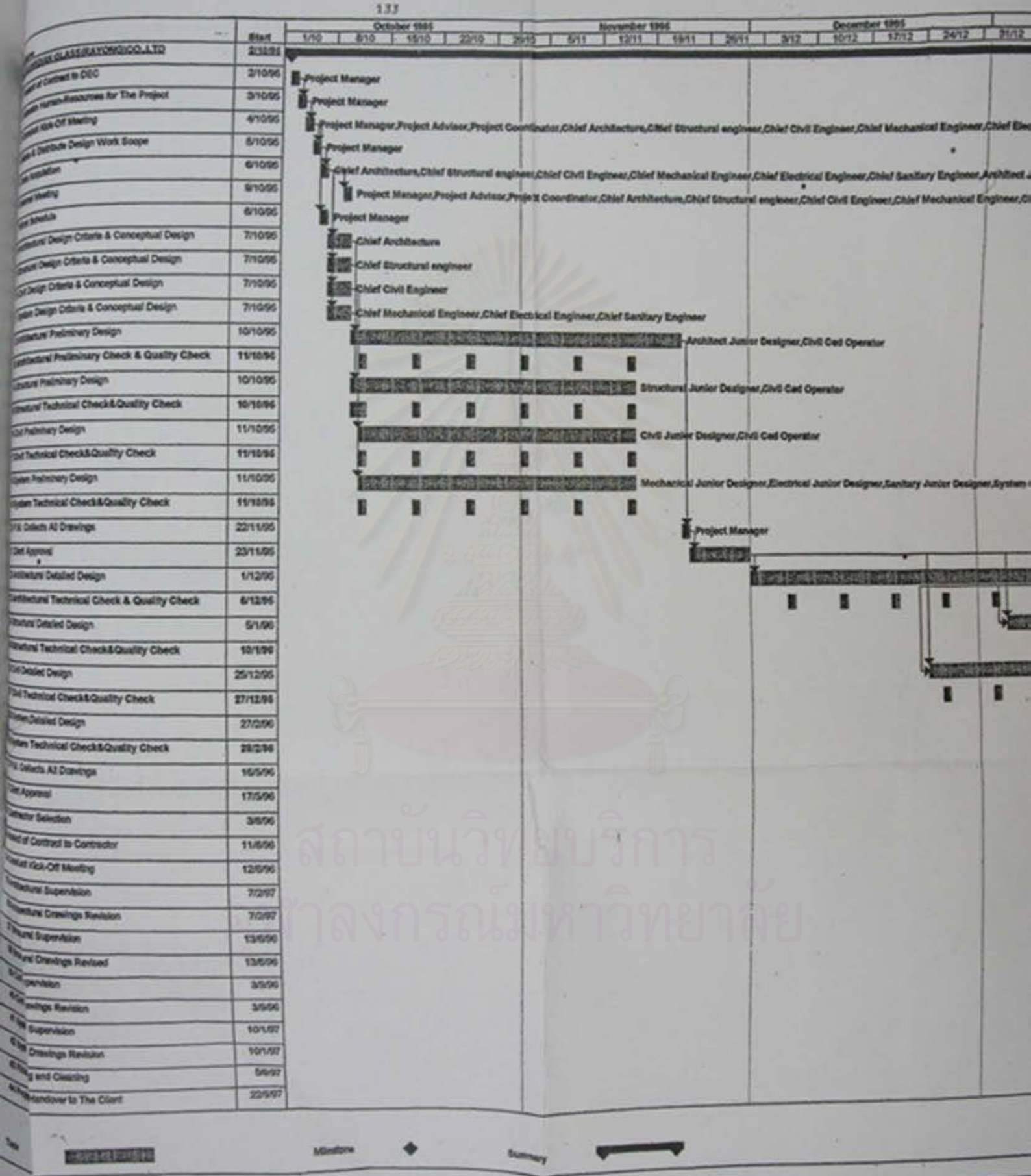
ii) 20% of the design fee is paid while the preliminary design is complete.

iii) 30% of the design fee is paid for completed design work.

iv) After half of the project has been built, 15% of the design fee is released.

v) The last 15% of the design fee is paid when the construction of project is complete.

The example of estimating the cost of design and supervision by developed method, Activity Breakdown Estimating Method, is done by using C Float Glass as an example.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Project Manager
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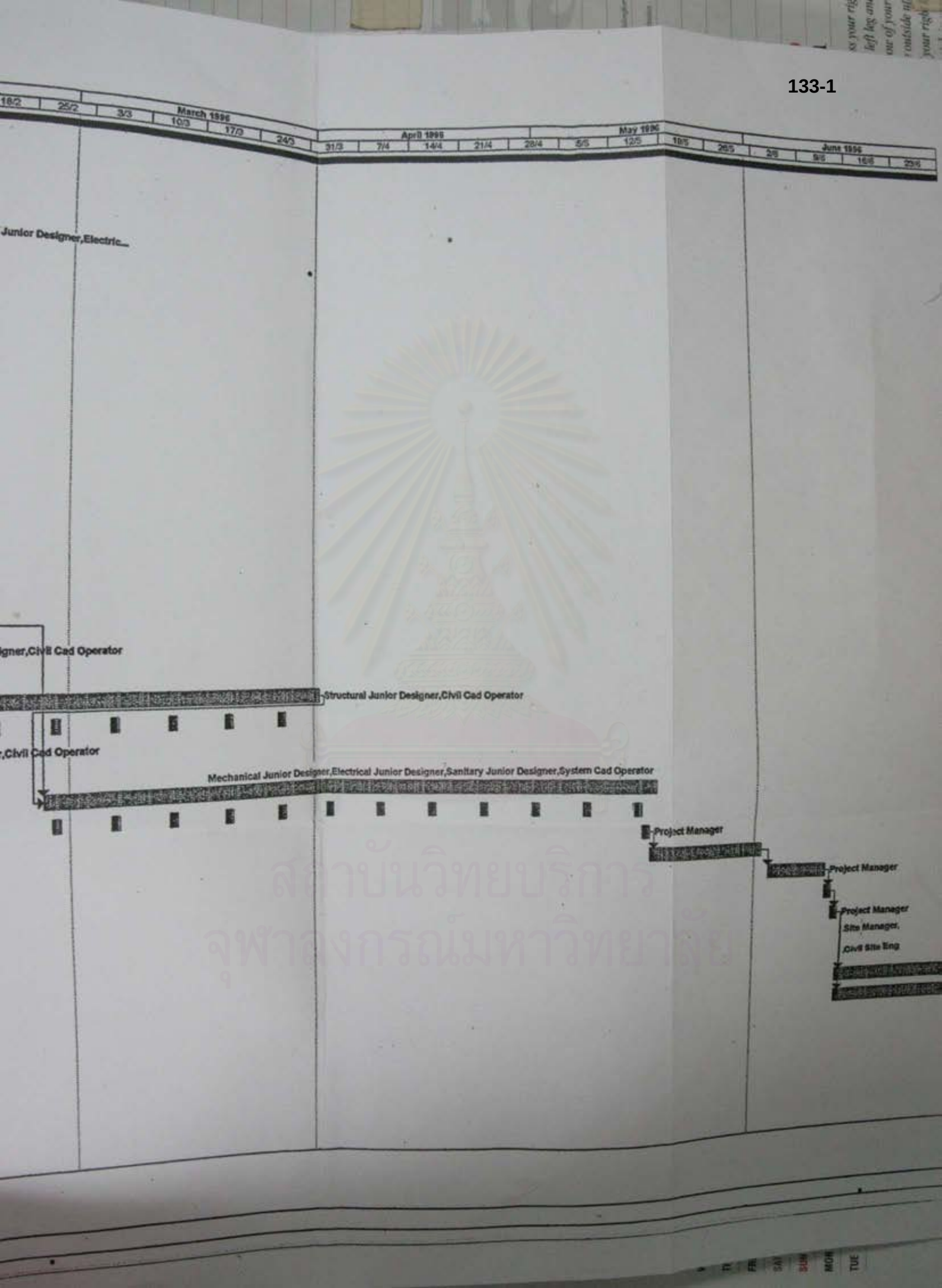
Chief Architecture
Chief Structural engineer
Chief Civil Engineer
Chief Mechanical Engineer,Chief Electrical Engineer,Chief Sanitary Engineer
Architect Junior Designer,Civil Cad Operator
Structural Junior Designer,Civil Cad Operator
Civil Junior Designer,Civil Cad Operator
Mechanical Junior Designer,Electrical Junior Designer,Sanitary Junior Designer,System
Project Manager
Milestone
Summary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Junior Designer,Electric...
Structural Junior Designer,Civil Cad Operator
Mechanical Junior Designer,Electrical Junior Designer,Sanitary Junior Designer,System Cad Operator
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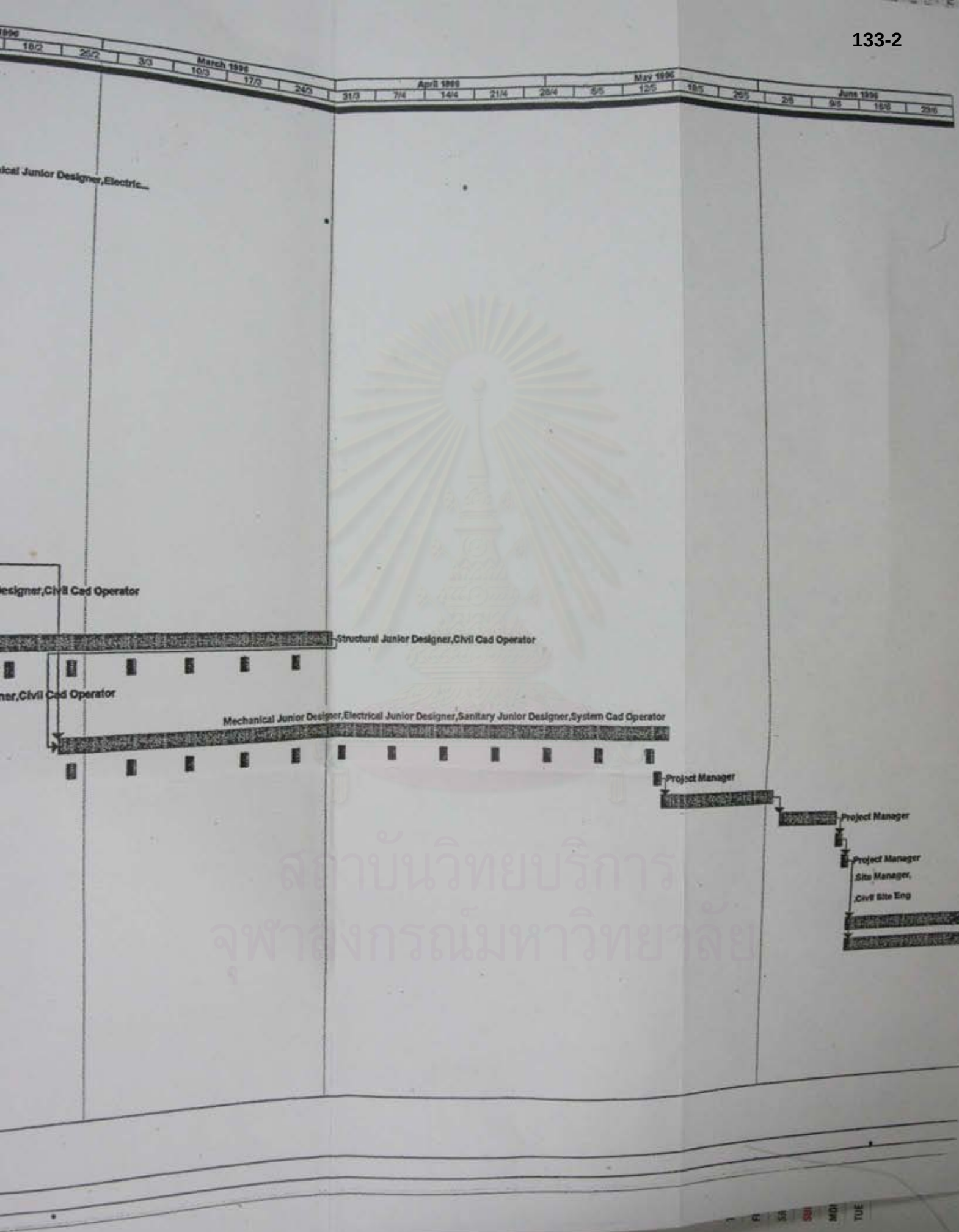
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Structural Junior Designer,Civil Cad Operator
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Mechanical Junior Designer,Electrical Junior Designer,Sanitary Junior Designer,System Cad Operator
Project Manager
Project Manager
Project Manager
Site Manager,
Civil Site Eng
MON
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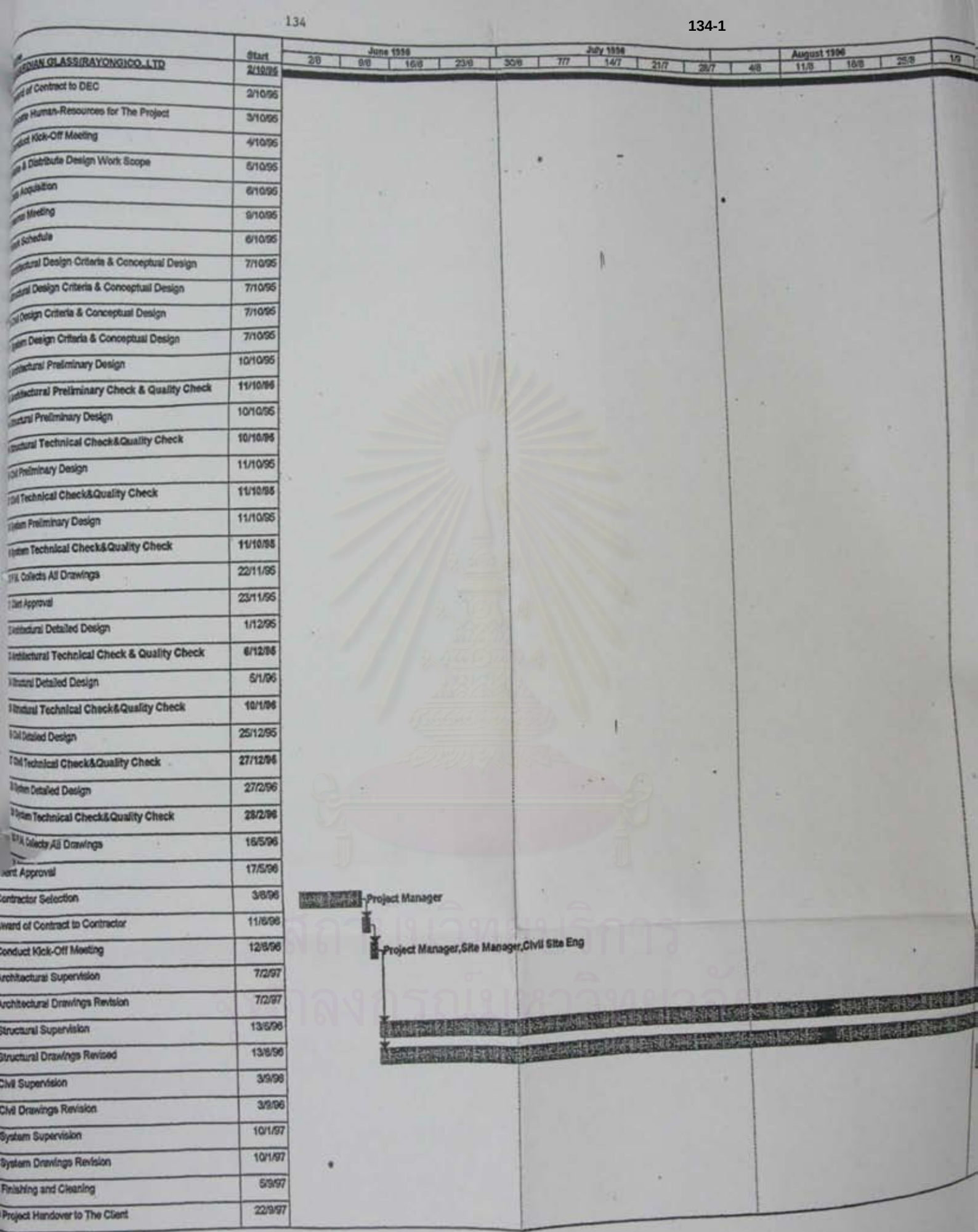
	Start
GUARDIAN GLASS(RAYONG)CO.,LTD	2/10/95
Award of Contract to DEC	2/10/95
Allocate Human-Resources for The Project	3/10/95
Conduct Kick-Off Meeting	4/10/95
Review & Distribute Design Work Scope	5/10/95
Land Acquisition	6/10/95
Progress Meeting	9/10/95
Project Schedule	6/10/95
Architectural Design Criteria & Conceptual Design	7/10/95
Structural Design Criteria & Conceptual Design	7/10/95
Civil Design Criteria & Conceptual Design	7/10/95
System Design Criteria & Conceptual Design	7/10/95
Architectural Preliminary Design	10/10/95
Architectural Preliminary Check & Quality Check	11/10/95
Structural Preliminary Design	10/10/95
Structural Technical Check&Quality Check	10/10/95
Civil Preliminary Design	11/10/95
Civil Technical Check&Quality Check	11/10/95
System Preliminary Design	11/10/95
System Technical Check&Quality Check	11/10/95
PM Collects All Drawings	22/11/95
Client Approval	23/11/95
Architectural Detailed Design	1/12/95
Architectural Technical Check & Quality Check	6/12/95
Structural Detailed Design	5/1/96
Structural Technical Check&Quality Check	10/1/96
Civil Detailed Design	25/12/95
Civil Technical Check&Quality Check	27/12/96
System Detailed Design	27/2/96
System Technical Check&Quality Check	28/2/96
PM Collects All Drawings	16/5/96
Client Approval	17/5/96
Contractor Selection	3/6/96
Award of Contract to Contractor	11/6/96
Conduct Kick-Off Meeting	12/6/96
Architectural Supervision	7/2/97
Architectural Drawings Revision	7/2/97
Structural Supervision	13/5/96
Structural Drawings Revised	13/6/96
Civil Supervision	3/9/96
Civil Drawings Revision	3/9/96
System Supervision	10/1/97
System Drawings Revision	10/1/97
Finishing and Cleaning	5/9/97
Project Handover to The Client	22/9/97



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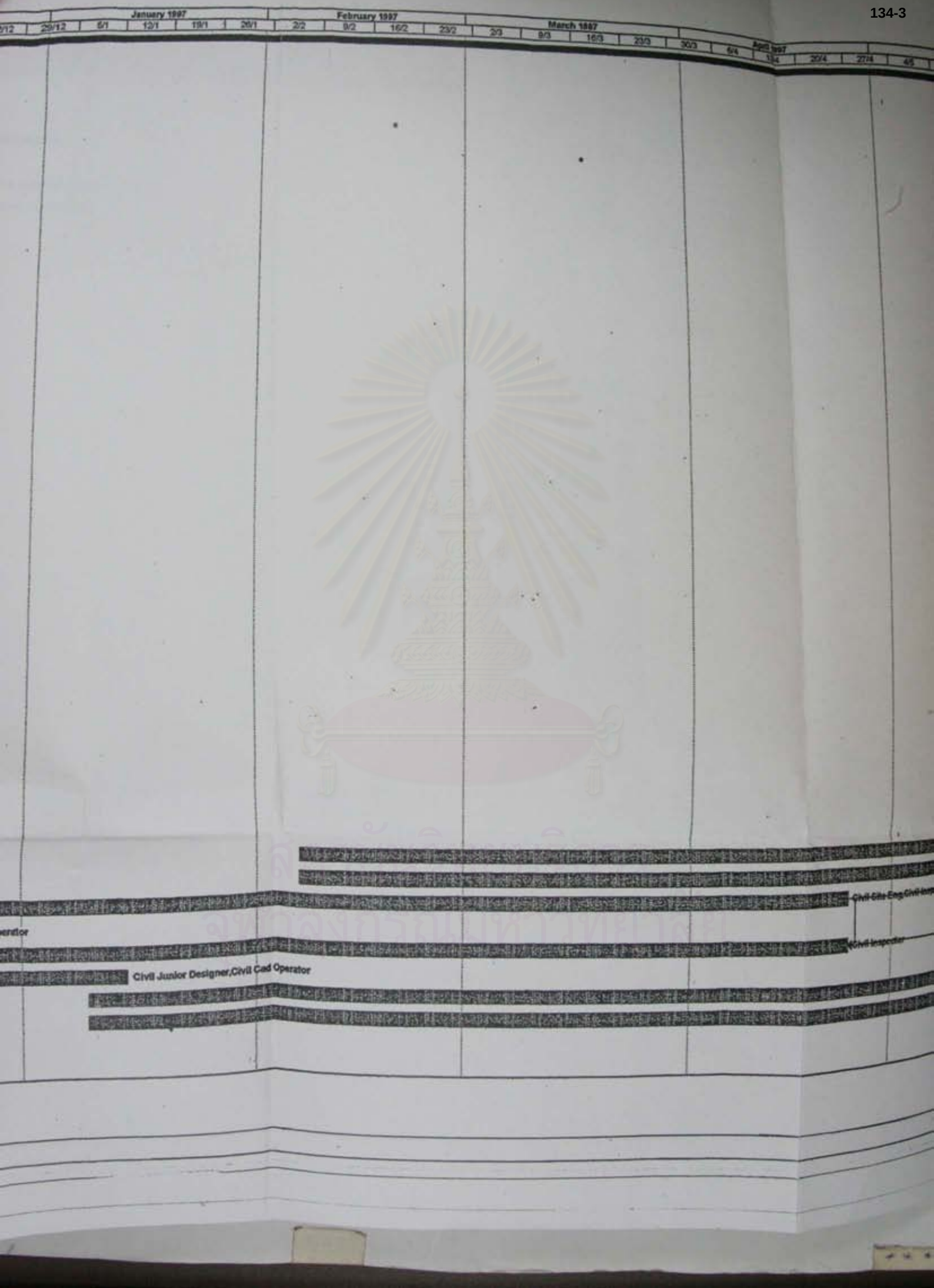
Structural Junior Designer,Civil Cad Operator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March 1997
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23/3
30/3
6/4
20/4
27/4
Civil Site Eng,Civil Insp
Civil Inspector
Civil Junior Designer,Civil Cad Operator

April 1997 | 13/4 | 20/4 | 27/4 | May 1997 | 4/5 | 11/5 | 18/5 | 25/5 | June 1997 | 1/6 | 8/6 | 15/6 | 22/6 | 29/6 | July 1997 | 6/7 | 13/7 | 20/7 | 27/7 | August 1997 | 3/8 | 10/8 | 17/8 | 24/8

Architect Junior Designer,Civil Cad Operator

Civil Site Eng,Civil Inspector

Civil Inspector

System Inspector,System Site Eng

System Cad Operator,Sanitary Junior Designer,Electrical Junior Designer,Mechanical Junior Designer

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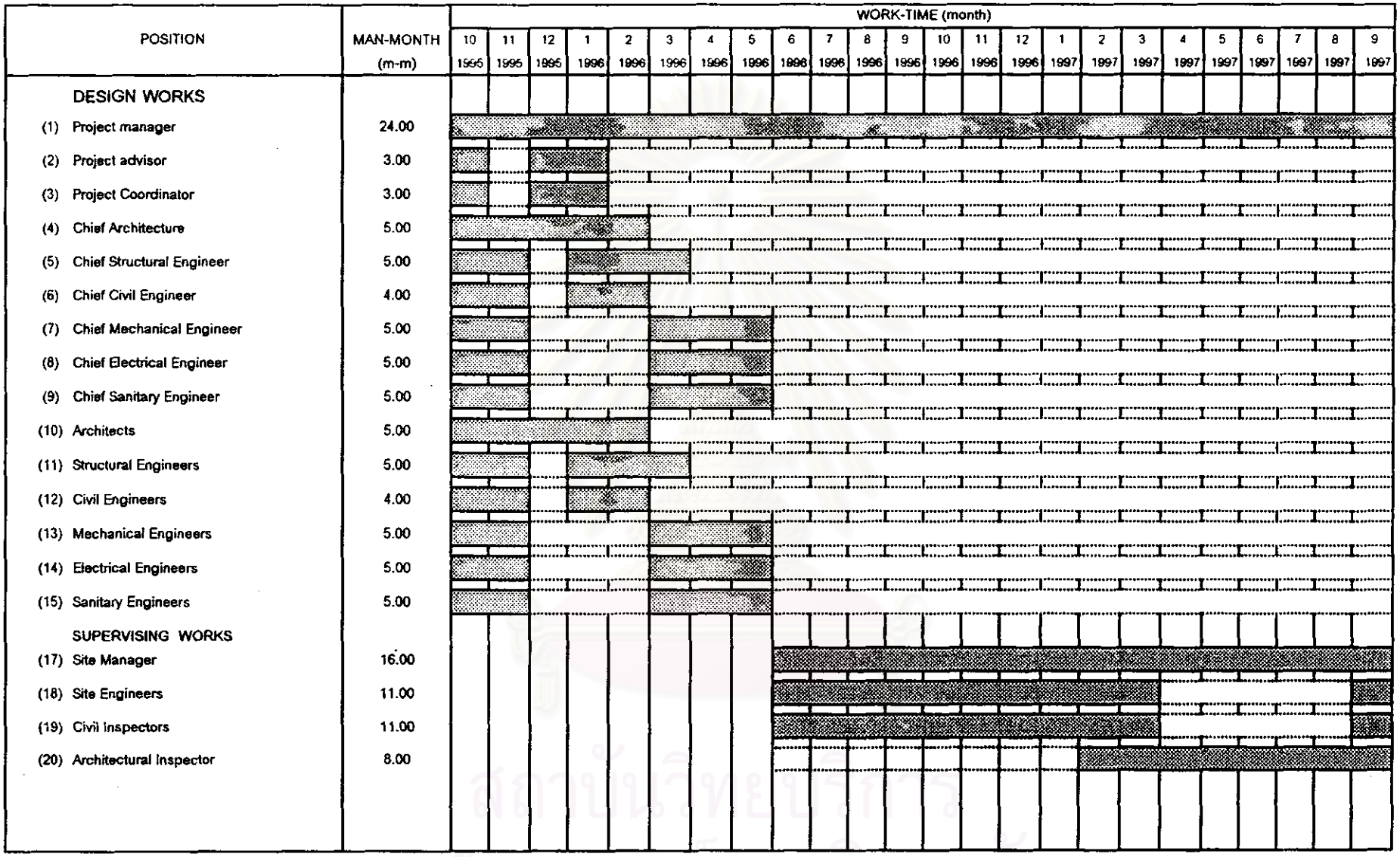
HUMAN RESOURCE PLANNING

POSITION	MAN-MONTH (m-m)
DESIGN WORKS	
(1) Project manager	24.00
(2) Project advisor	3.00
(3) Project Coordinator	3.00
(4) Chief Architecture	5.00
(5) Chief Structural Engineer	5.00
(6) Chief Civil Engineer	4.00
(7) Chief Mechanical Engineer	5.00
(8) Chief Electrical Engineer	5.00
(9) Chief Sanitary Engineer	5.00
(10) Architects	5.00
(11) Structural Engineers	5.00
(12) Civil Engineers	4.00
(13) Mechanical Engineers	5.00
(14) Electrical Engineers	5.00
(15) Sanitary Engineers	5.00
SUPERVISING WORKS	
(17) Site Manager	16.00
(18) Site Engineers	11.00
(19) Civil Inspectors	11.00
(20) Architectural Inspector	8.00



REMARKS: FULL-TIME

PART-TIME

THE EXAMPLE OF ACTIVITY BREAKDOWN METHOD

Description of Key Staff Salary

A. Consultant Co.,Ltd.

Project : C. Float Glass II ; Rayong , THAILAND.

Date : 1 October 1995

		1	2	3	4	5	6
No.	POSITION	BASE SALARY (Baht/Month)	SOCIAL CHARGE (Baht/Month) 35% of 1	OVERHEAD COST (Baht/Month) 60% of 1	TOTAL (Baht/Month) 1+2+3	FEE (Baht/Month) 10% of 4	PROPOSED SALARY (Baht) 4+5
1	Project Manager	80,000	28,000	48,000	156,000	15,600	171,600
2	Site Manager	75,000	26,250	45,000	146,250	14,625	160,875
3	Project Advisor	60,000	21,000	36,000	117,000	11,700	128,700
4	Project Coordinator	50,000	17,500	30,000	97,500	9,750	107,250
5	Chief Architect	70,000	24,500	42,000	136,500	13,650	150,150
6	Chief Structural Enegineer	70,000	24,500	42,000	136,500	13,650	150,150
7	Chief Civil Engineer	70,000	24,500	42,000	136,500	13,650	150,150
8	Chief Mechanical Engineer	70,000	24,500	42,000	136,500	13,650	150,150
9	Chief Electrical Engineer	70,000	24,500	42,000	136,500	13,650	150,150
10	Chief Sanitary Engineer	70,000	24,500	42,000	136,500	13,650	150,150
11	Site Engineer	35,000	12,250	21,000	68,250	6,825	75,075
12	Architect	30,000	10,500	18,000	58,500	5,850	64,350
13	Structural Engineer	30,000	10,500	18,000	58,500	5,850	64,350
14	Civil Engineer	30,000	10,500	18,000	58,500	5,850	64,350
15	Mechanical Engineer	30,000	10,500	18,000	58,500	5,850	64,350
16	Electrical Engineer	30,000	10,500	18,000	58,500	5,850	64,350
17	Sanitary Engineer	30,000	10,500	18,000	58,500	5,850	64,350
18	Inspector	20,000	7,000	12,000	39,000	3,900	42,900
19	CAD Operator	16,000	5,600	9,600	31,200	3,120	34,320
20	Secretary	15,000	5,250	9,000	29,250	2,925	32,175
21	Cleark	10,000	3,500	6,000	19,500	1,950	21,450
22	Driver, Messenger	8,000	2,800	4,800	15,600	1,560	17,160

KEY STAFF COST

	POSITION (Amount)	Man-Month	Man-Month x Amount	Rate of Salary (Baht)	Total Amount (Baht)
1.	Project Manager (1)	24.00	24.00	171,600	4,118,400
2.	Site Manager (1)	16.00	16.00	160,875	2,574,000
3.	Project Advisor (1)	3.00	3.00	128,700	386,100
4.	Project Coordinator (1)	3.00	3.00	107,250	321,750
5.	Chief Architect (1)	5.00	5.00	150,150	750,750
6.	Chief Structural Engineer (1)	5.00	5.00	150,150	750,750
7.	Chief Civil Engineer (1)	4.00	4.00	150,150	600,600
8.	Chief Mechanical Engineer (1)	5.00	5.00	150,150	750,750
9.	Chief Electrical Engineer (1)	5.00	5.00	150,150	750,750
10.	Chief Sanitary Engineer (1)	5.00	5.00	150,150	750,750
11.	Site Engineers (2)	11.00	22.00	75,075	1,651,650
12.	Architects (2)	5.00	10.00	64,350	643,500
13.	Structural Engineers (4)	5.00	20.00	64,350	1,287,000
14.	Civil Engineers (1)	4.00	4.00	64,350	257,400
15.	Mechanical Engineers (2)	5.00	10.00	64,350	643,500
16.	Electrical Engineers (2)	5.00	10.00	64,350	643,500
17.	Sanitary Engineers (2)	5.00	10.00	64,350	643,500
	TOTAL AMOUNT OF KEY STAFF COST				17,524,650

SUPPORTED STAFF COST

	POSITION (Amount)	Man-Month	Man-Month x Amount	Rate of Salary (Baht)	Total Amount (Baht)
1.	Cad Operators (4)	9.00	36.00	34,320	1,235,520
2.	Inspectors (4 , 1)	11.00 , 8.00	52.00	42,900	2,230,800
3.	Secretaries (2)	14.00	28.00	32,175	900,900
4.	Clearks (2)	8.00	16.00	21,450	343,200
5	Drivers, Messengers (2)	8.00	16.00	17,160	274,560
			TOTAL AMOUNT OF SUPPORTED STAFF COST		4,984,980

TOTAL COST OF THE PROJECT

1.	Total Amount of Key Staff Cost	17,524,650	Baht
2.	Total Amount of Supported Staff Cost	4,984,980	Baht
3.	Reimbursable Cost	1,067,000	Baht
	Total Cost of The Project	23,576,630	Baht
	Include 7% VAT (Value Added Tax)	1,650,364	Baht
	Grand Total Cost of The Project	**25,226,994**	**Baht**

REIMBURSABLE COST

	Unit	Quantities	Cost/Unit	Total (Baht)
OFFICE EXPENSE				
Telecommuncation Cost	month	20	8,000	160,000
Miscellaneous Cost	month	20	10,000	200,000
Computer and Equipment Cost	month	14	10,000	140,000
FIELD EXPENSE				
Accommodation Cost	man-month	82	2,000	164,000
Vehicle Cost	lump-sum	-	-	150,000
Bus Fare	trip-head	60	500	30,000
REPORT AND DOCUMENT COST				
Design Criteria Report	issue	5	1,000	5,000
Preliminary Drawings	issue	3	4,500	13,500
Detailed Drawings	issue	5	10,000	50,000
Detailed Calculation	issue	3	1,500	4,500
Drawing Revision	lump-sum	-	-	40,000
Final Drawings	issue	10	10,000	100,000
Final Report (estimating of quantities and construction)	issue	5	2,000	10,000
TOTAL AMOUNT OF REIMBURSABLE COST				1,067,000

No.	POSITION	BASE SALARY (Baht/Month)
1	Project Manager	80,000
2	Site Manager	75,000
3	Project Advisor	60,000
4	Project Coordinator	50,000
5	Chief Architect	70,000
6	Chief Structural Enegineer	70,000
7	Chief Civil Engineer	70,000
8	Chief Mechanical Engineer	70,000
9	Chief Electrical Engineer	70,000
10	Chief Sanitary Engineer	70,000
11	Site Engineer	35,000
12	Architect	30,000
13	Structural Engineer	30,000
14	Civil Engineer	30,000
15	Mechanical Engineer	30,000
16	Electrical Engineer	30,000
17	Sanitary Engineer	30,000
18	Inspector	20,000
19	CAD Operator	16,000
20	Secretary	15,000
21	Cleark	10,000
22	Driver, Messenger	8,000

Table 4.9 : Basic Salary of A. Consultants Co.,Ltd.

From the example, the cost for design and supervision that the company propose to the owner is 25,226,994 baht. The project time is 24 months.

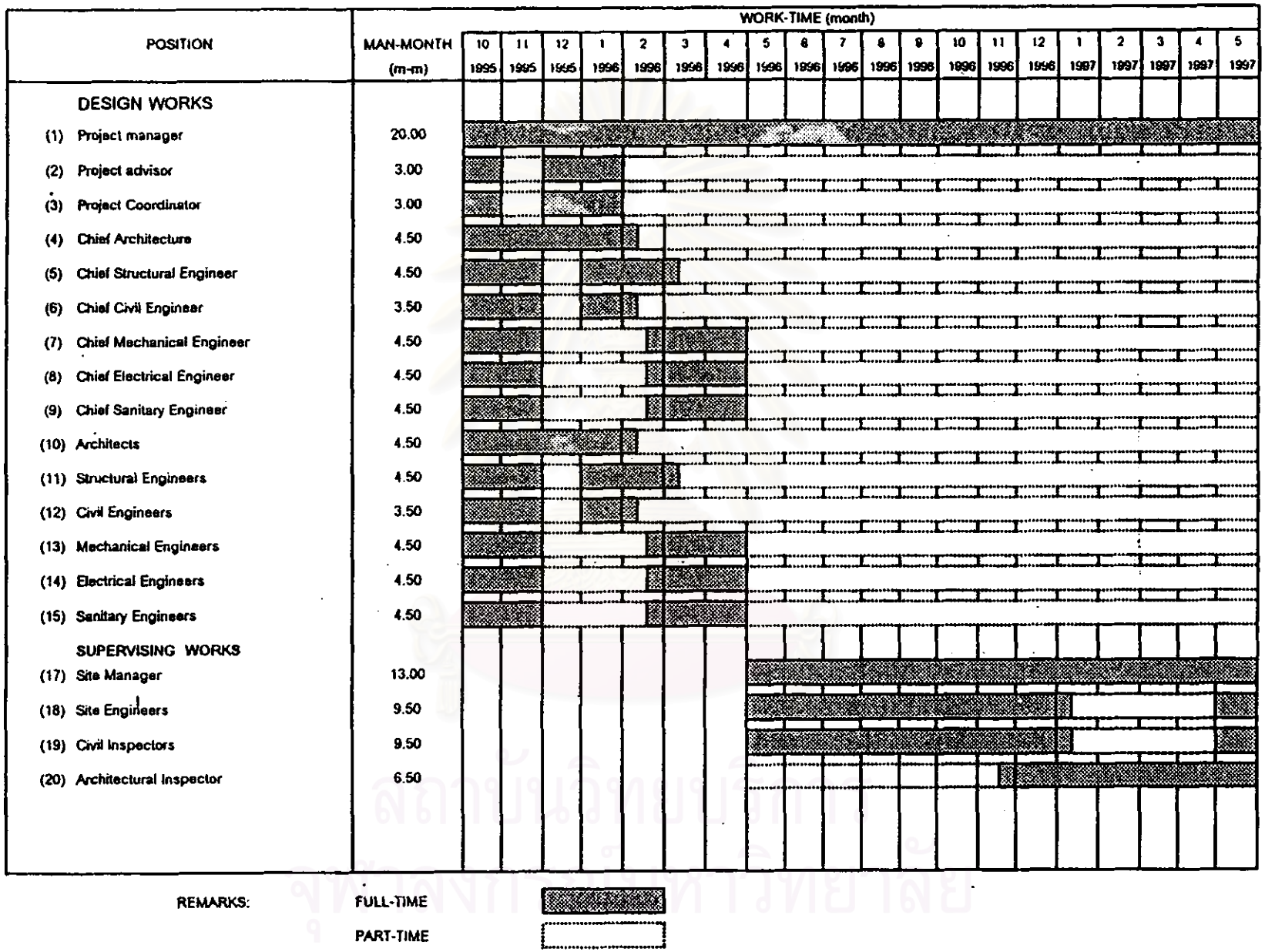
The cost can properly be adjustec by this method. If the owners would like to finish the project in 20 months, the company can determine the projet cost to purpose to them. The caluclations are as follow:

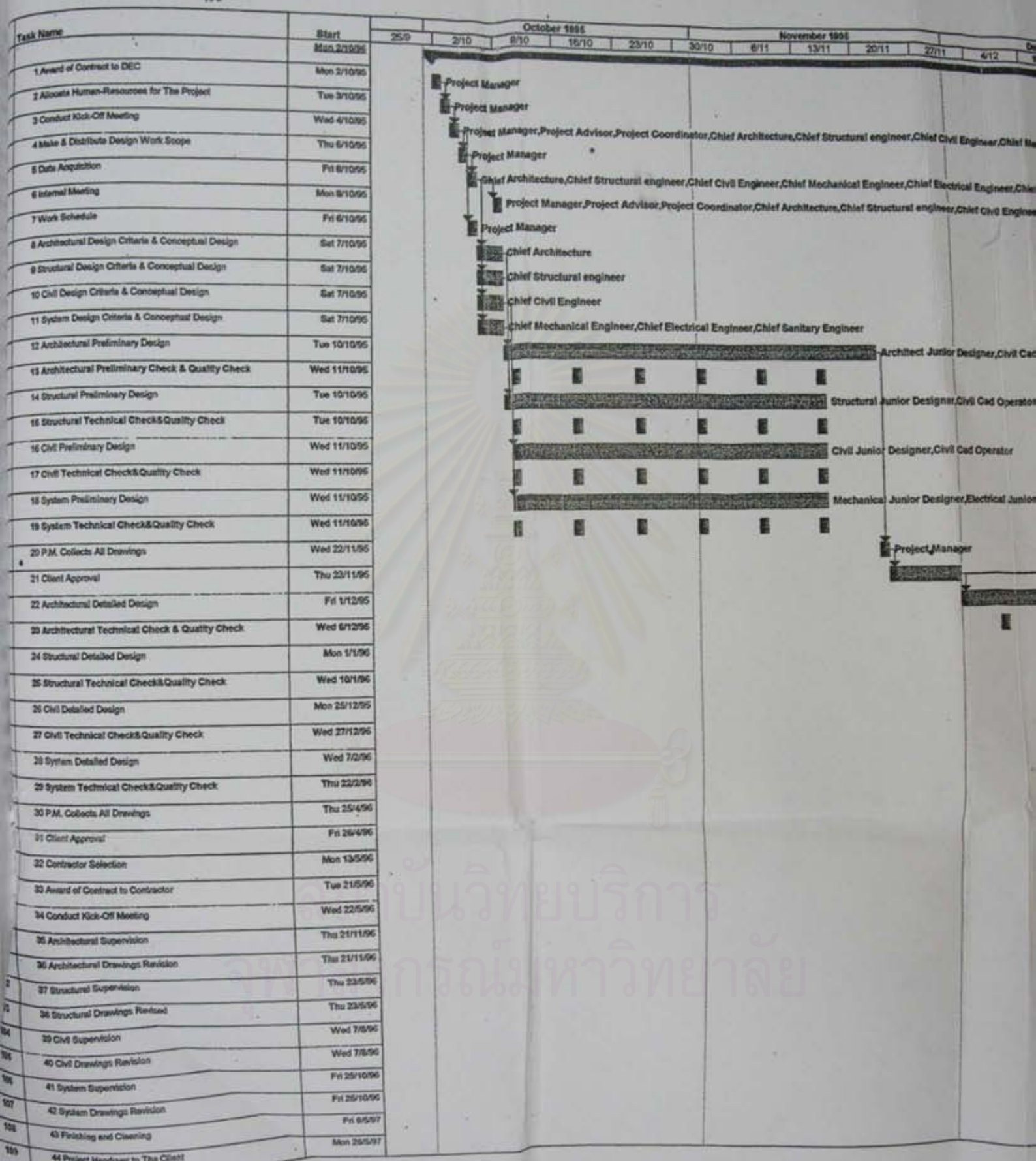
ACTIVITIES IN THE PROJECT

ITEM	ACTIVITIES	MAN	TIME	TYPE
1	Awards of Contract to DEC	1	1	FIX
2	Allocate Human-Resources for the Project	1	1	FIX
3	Conduct Kick-Off Meeting	1	1	FIX
4	Make & Distribute Design Work Scope	1	1	FIX
5	Data Acquisition	1	1	FIX
6	Internal Meeting	1	1	FIX
7	Work Schedule	1	1	FIX
8	Architectural Design Criteria & Conceptual Design	1	2	DRIVEN
9	Structural Design Criteria & Conceptual Design	1	2	DRIVEN
10	Civil Design Criteria & Conceptual Design	1	2	DRIVEN
11	System Design Criteria & Conceptual Design	1	2	DRIVEN
12	Architectural Preliminary Design	2	37	DRIVEN
13	Architectural Preliminary Check & Quality Check	1	31	DRIVEN
14	Structural Preliminary Design	4	32	DRIVEN
15	Structural Preliminary Check & Quality Check	1	32	DRIVEN
16	Civil Preliminary Design	1	31	DRIVEN
17	Civil Preliminary Check & Quality Check	1	31	DRIVEN
18	System Preliminary Design	6	31	DRIVEN
19	System Preliminary Check & Quality Check	1	31	DRIVEN
20	P.M. Collects all Drawings	1	1	FIX
21	Client Approval	1	7	FIX
22	Architectural Detailed Design	2	60	DRIVEN
23	Architectural Technical Check & Quality Check	1	55	DRIVEN
24	Structural Detailed Design	4	75	DRIVEN
25	Structural Technical Check & Quality Check	1	67	DRIVEN
26	Civil Detailed Design	1	40	DRIVEN

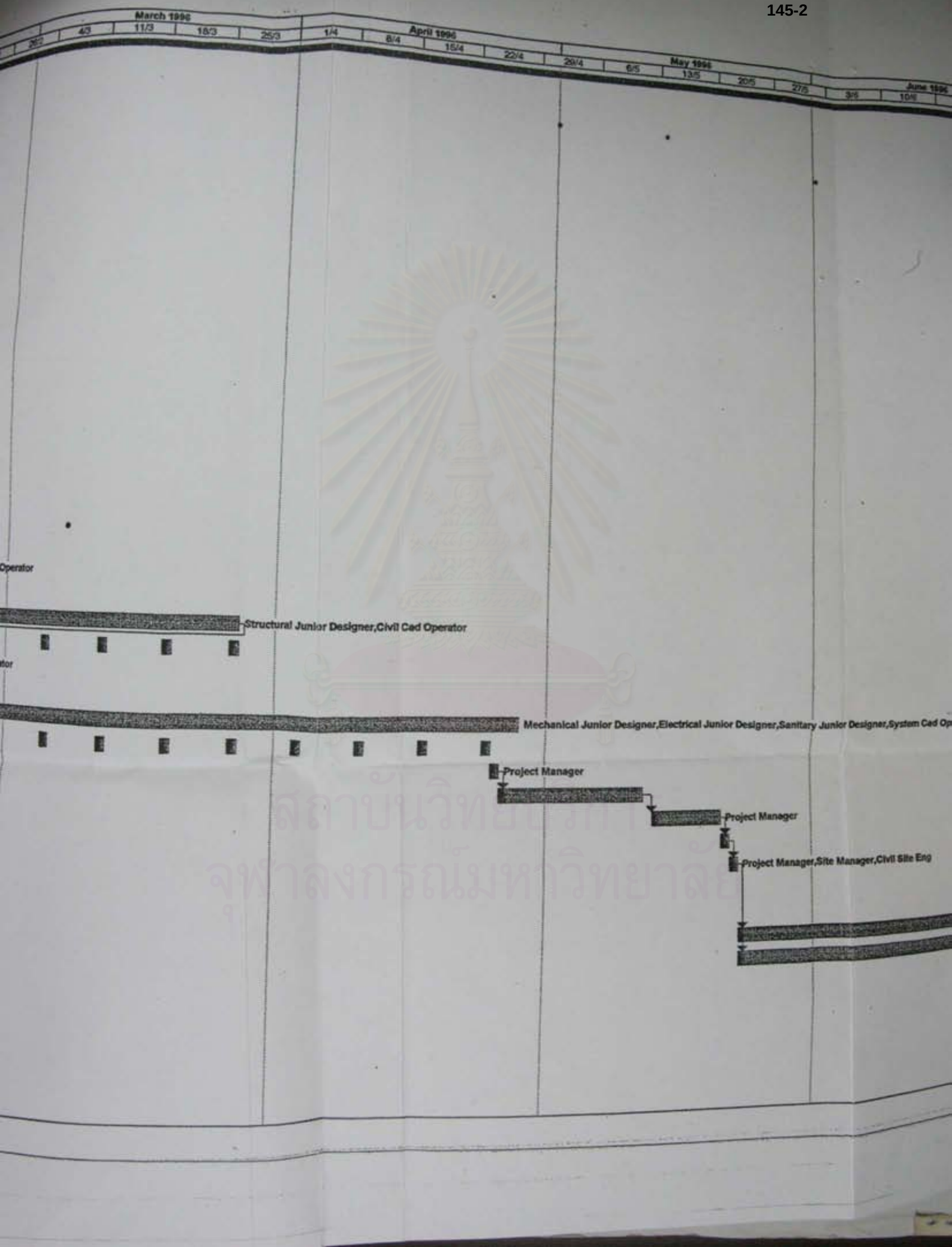
ITEM	ACTIVITIES	MAN	TIME	TYPE
27	Civil Technical Check & Quality Check	1	37	DRIVEN
28	System Detailed Design	6	70	DRIVEN
29	System Technical Check & Quality Check	1	67	DRIVEN
30	P.M. Collects all Drawings	1	1	FIX
31	Client Approval	1	14	FIX
32	Contractor Selection	1	7	FIX
33	Awards of Contract to Contractor	1	1	FIX
34	Conduct Kick-Off Meeting	1	1	FIX
35	Architectural Supervision	1	180	DRIVEN
36	Architectural Drawings Revision	1	120	DRIVEN
37	Structural Supervision	2	270	DRIVEN
38	Structural Drawings Revision	1	150	DRIVEN
39	Civil Supervision	1	200	DRIVEN
40	Civil Drawings Revision	1	115	DRIVEN
41	System Supervision	3	150	DRIVEN
42	System Drawings Revision	3	115	DRIVEN
43	Finishing and Cleaning	1	15	FIX
44	Project Handover to the Client	1	0	FIX

HUMAN RESOURCE PLANNING

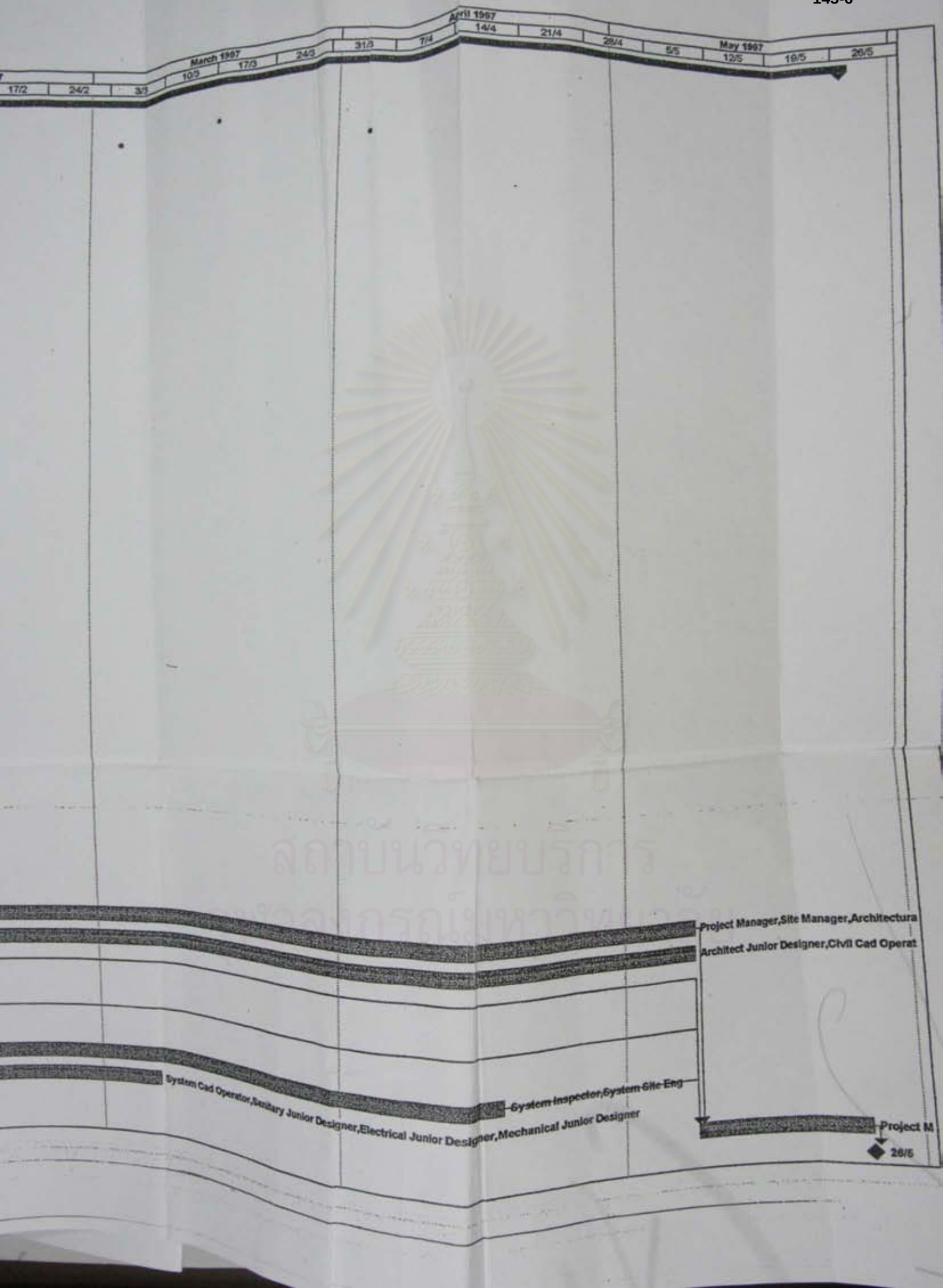




	Task Name	Start
		Mon 2/10/95
1	Award of Contract to DEC	Mon 2/10/95
2	Allocate Human-Resources for The Project	Tue 3/10/95
3	Conduct Kick-Off Meeting	Wed 4/10/95
4	Make & Distribute Design Work Scope	Thu 5/10/95
5	Data Acquisition	Fri 6/10/95
6	Internal Meeting	Mon 9/10/95
7	Work Schedule	Fri 6/10/95
8	Architectural Design Criteria & Conceptual Design	Sat 7/10/95
9	Structural Design Criteria & Conceptual Design	Sat 7/10/95
10	Civil Design Criteria & Conceptual Design	Sat 7/10/95
11	System Design Criteria & Conceptual Design	Sat 7/10/95
12	Architectural Preliminary Design	Tue 10/10/95
13	Architectural Preliminary Check & Quality Check	Wed 11/10/95
14	Structural Preliminary Design	Tue 10/10/95
15	Structural Technical Check&Quality Check	Tue 10/10/95
16	Civil Preliminary Design	Wed 11/10/95
17	Civil Technical Check&Quality Check	Wed 11/10/95
18	System Preliminary Design	Wed 11/10/95
19	System Technical Check&Quality Check	Wed 11/10/95
20	P.M. Collects All Drawings	Wed 22/11/95
21	Client Approval	Thu 23/11/95
22	Architectural Detailed Design	Fri 1/12/95
23	Architectural Technical Check & Quality Check	Wed 6/12/95
24	Structural Detailed Design	Mon 1/1/96
25	Structural Technical Check&Quality Check	Wed 10/1/96
26	Civil Detailed Design	Mon 25/12/95
27	Civil Technical Check&Quality Check	Wed 27/12/95
28	System Detailed Design	Wed 7/2/96
29	System Technical Check&Quality Check	Thu 22/2/96
30	P.M. Collects All Drawings	Thu 25/4/96
31	Client Approval	Fri 26/4/96
32	Contractor Selection	Mon 13/5/96
33	Award of Contract to Contractor	Tue 21/5/96
34	Conduct Kick-Off Meeting	Wed 22/5/96
35	Architectural Supervision	Thu 21/11/96
36	Architectural Drawings Revision	Thu 21/11/96
37	Structural Supervision	Thu 23/5/96
38	Structural Drawings Revised	Thu 23/5/96
39	Civil Supervision	Wed 7/8/96
40	Civil Drawings Revision	Wed 7/8/96
41	System Supervision	Fri 25/10/96
42	System Drawings Revision	Fri 25/10/96
43	Finishing and Cleaning	Fri 6/5/97
44	Project Handover to The Client	Mon 26/5/97


March 1996
4/3
11/3
18/3
25/3
1/4
April 1996
8/4
15/4
22/4
29/4
6/5
May 1996
13/5
20/5
27/5
3/6
10/6
June 1996
Operator
Structural Junior Designer,Civil Cad Operator
Mechanical Junior Designer,Electrical Junior Designer,Sanitary Junior Designer,System Cad Op
Project Manager
Project Manager
Project Manager,Site Manager,Civil Site Eng


1996
18/11
25/11
2/12
December 1996
9/12
16/12
23/12
30/12
January 1997
6/1
13/1
20/1
27/1
3/2
February 1997
10/2
17/2
24/2
3/3
Junior Designer,Civil Cad Operator
Civil Site Eng,Civil Inspector
Civil Junior Designer,Civil Cad Operator
Civil Inspector


March 1997
17/2
24/2
3/3
10/3
17/3
24/3
31/3
7/4
April 1997
14/4
21/4
28/4
5/5
May 1997
12/5
19/5
26/5
Project Manager,Site Manager,Architectura
Architect Junior Designer,Civil Cad Operat
System Cad Operator,Sanitary Junior Designer,Electrical Junior Designer,Mechanical Junior Designer
System Inspector,System Site Eng
Project M
26/5

KEY STAFF COST

	POSITION (Amount)	Man-Month	Man-Month x Amount	Rate of Salary (Baht)	Total Amount (Baht)
1.	Project Manager (1)	20.00	20.00	171,600	3,432,000
2.	Site Manager (1)	13.00	13.00	160,875	2,091,375
3.	Project Advisor (1)	3.00	3.00	128,700	386,100
4.	Project Coordinator (1)	3.00	3.00	107,250	321,750
5.	Chief Architect (1)	4.50	4.50	150,150	675,675
6.	Chief Structural Engineer (1)	4.50	4.50	150,150	675,675
7.	Chief Civil Engineer (1)	3.50	3.50	150,150	525,525
8.	Chief Mechanical Engineer (1)	4.50	4.50	150,150	675,675
9.	Chief Electrical Engineer (1)	4.50	4.50	150,150	675,675
10.	Chief Sanitary Engineer (1)	4.50	4.50	150,150	675,675
11.	Site Engineers (4)	9.50	38.00	75,075	2,852,850
12.	Architects (3)	4.50	13.50	64,350	868,725
13.	Structural Engineers (5)	4.50	22.50	64,350	1,447,875
14.	Civil Engineers (2)	3.50	7.00	64,350	450,450
15.	Mechanical Engineers (3)	4.50	13.50	64,350	868,725
16.	Electrical Engineers (3)	4.50	13.50	64,350	868,725
17.	Sanitary Engineers (3)	4.50	13.50	64,350	868,725
	TOTAL AMOUNT OF KEY STAFF COST				18,361,200

SUPPORTED STAFF COST

	POSITION (Amount)	Man-Month	Man-Month x Amount	Rate of Salary (Baht)	Total Amount (Baht)
1.	Cad Operators (6)	8.00	48.00	34,320	1,647,360
2.	Inspectors (6 , 2)	9.50 , 6.50	70.00	42,900	3,003,000
3.	Secretaries (2)	14.00	28.00	32,175	900,900
4.	Clearks (2)	8.00	16.00	21,450	343,200
5	Drivers, Messengers (2)	8.00	16.00	17,160	274,560
			TOTAL AMOUNT OF SUPPORTED STAFF COST		6,169,020

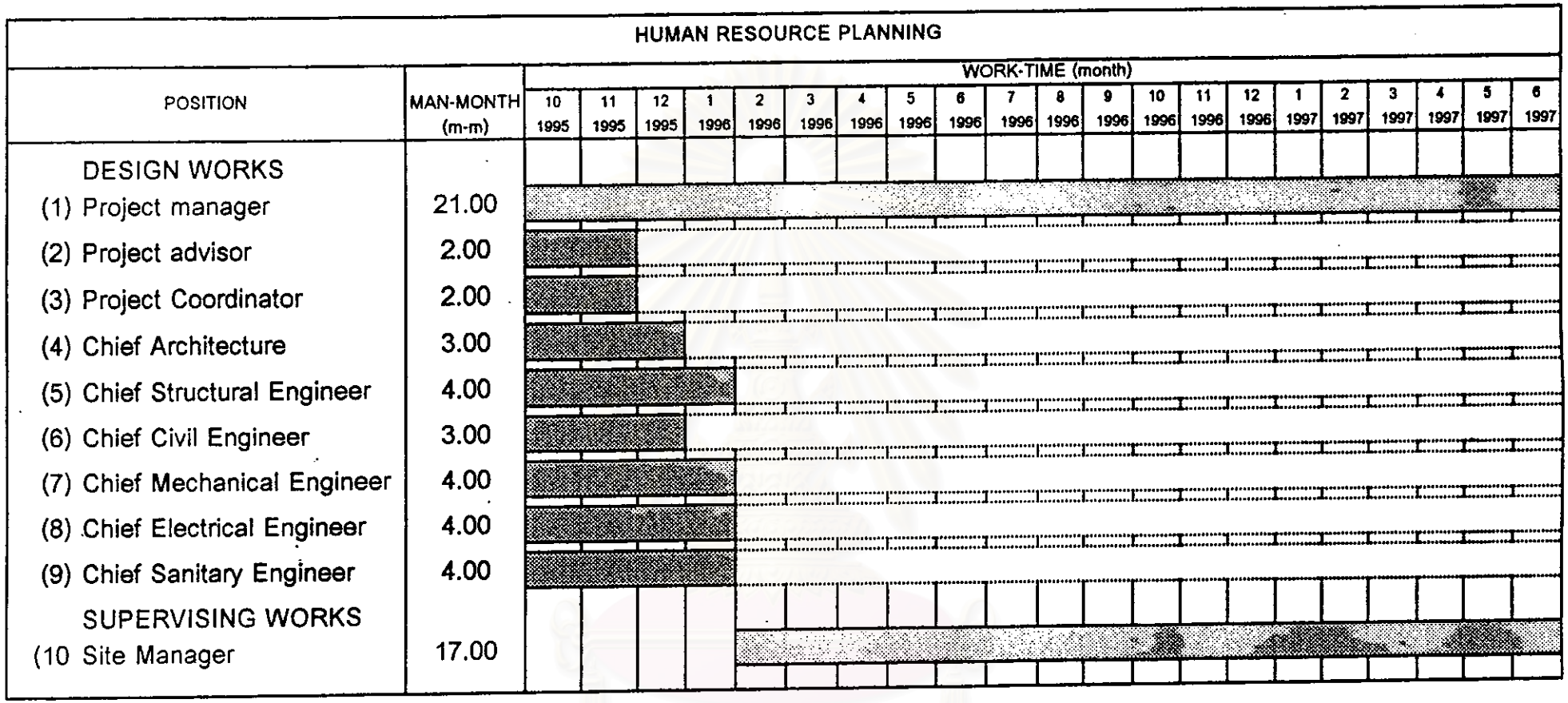
TOTAL COST OF THE PROJECT

1.	Total Amount of Key Staff Cost	18,361,200	Baht
2.	Total Amount of Supported Staff Cost	6,169,020	Baht
3.	Reimbursable Cost	1,067,000	Baht
4.	Extra Payment for Key Staff	200,000	Baht
	Total Cost of The Project	25,797,220	Baht
	Include 7% VAT (Value Added Tax)	1,805,805	Baht
	Grand Total Cost of The Project	27,603,025	Baht

REIMBURSABLE COST

	Unit	Quantities	Cost/Unit	Total (Baht)
OFFICE EXPENSE				
Telecommuncation Cost	month	20	8,000	160,000
Miscellaneous Cost	month	20	10,000	200,000
Computer and Equipment Cost	month	14	10,000	140,000
FIELD EXPENSE				
Accommodation Cost	man-month	82	2,000	164,000
Vehicle Cost	lump-sum	-	-	150,000
Bus Fare	trip-head	60	500	30,000
REPORT AND DOCUMENT COST				
Design Criteria Report	issue	5	1,000	5,000
Preliminary Drawings	issue	3	4,500	13,500
Detailed Drawings	issue	5	10,000	50,000
Detailed Calculation	issue	3	1,500	4,500
Drawing Revision	lump-sum	-	-	40,000
Final Drawings	issue	10	10,000	100,000
Final Report (estimating of quantities and construction)	issue	5	2,000	10,000
TOTAL AMOUNT OF REIMBURSABLE COST				1,067,000

HUMAN RESOURCE PLANNING



REMARKS: FULL-TIME

PART-TIME

THE EXAMPLE OF CONCEPTUAL METHOD

Description of Key Staff Salary

A. Consultant Co.,Ltd.

Projec : C. Float Glass II ; Rayong , THAILAND.

Date : 1 October 1995

		4	5	6	7	8	9
No.	POSITION	BASE SALARY (Baht/Month)	SOCIAL CHARGE (Baht/Month) 35% of 1	OVERHEAD COST (Baht/Month) 60% of 1	TOTAL (Baht/Month) 1+2+3	FEE (Baht/Month) 10% of 4	PROPOSED SALARY (Baht) 4+5
1	Project Manager	80,000	28,000	48,000	156,000	15,600	171,600
2	Site Manager	75,000	26,250	45,000	146,250	14,625	160,875
3	Project Advisor	60,000	21,000	36,000	117,000	11,700	128,700
4	Project Coordinator	50,000	17,500	30,000	97,500	9,750	107,250
5	Chief Architect	70,000	24,500	42,000	136,500	13,650	150,150
6	Chief Structural Enegineer	70,000	24,500	42,000	136,500	13,650	150,150
7	Chief Civil Engineer	70,000	24,500	42,000	136,500	13,650	150,150
8	Chief Mechanical Engineer	70,000	24,500	42,000	136,500	13,650	150,150
9	Chief Electrical Engineer	70,000	24,500	42,000	136,500	13,650	150,150
10	Chief Sanitary Engineer	70,000	24,500	42,000	136,500	13,650	150,150

KEY STAFF COST

	POSITION (Amount)	Man-Month	Man-Month x Amount	Rate of Salary (Baht)	Total Amount (Baht)
1	Project Manager (1)	21.00	21.00	171,600	3,603,600
2	Site Manager (1)	17.00	17.00	160,875	2,734,875
3	Project Advisor (1)	2.00	2.00	128,700	257,400
4	Project Coordinator (1)	2.00	2.00	107,250	214,500
5	Chief Architect (1)	3.00	3.00	150,150	450,450
6	Chief Structural Engineer (1)	4.00	4.00	150,150	600,600
7	Chief Civil Engineer (1)	3.00	3.00	150,150	450,450
8	Chief Mechanical Engineer (1)	4.00	4.00	150,150	600,600
9	Chief Electrical Engineer (1)	4.00	4.00	150,150	600,600
10	Chief Sanitary Engineer (1)	4.00	4.00	150,150	600,600
	TOTAL AMOUNT OF KEY STAFF COST				10,113,675

TOTAL COST OF THE PROJECT

1. Total Amount of Key Staff Cost	10,113,675	Baht
2. Support Staff Cost (only design phase)	4,000,000	Baht
3. Direct Cost	800,000	Baht
4. Construction Supervision Cost (not include site manager)	5,000,000	Baht
Total Cost of The Project	19,913,675	Baht
Include 7% VAT (Value Added Tax)	1,393,957	Baht
Grand Total Cost of The Project	21,307,632	Baht

4.8.4 THE ADVANTAGES OF NEW METHOD COMPARED WITH THE EXIXTING METHODS

a) In the existing methods, the activities in work procedures are not considered. The man hours of key staff are estimated from the experviences of estimator. It may not be close to the real prices. In the activity breakdown method, all of activities are considered so the estimated cost are based on the real activities. Thus, the cost from the new method should be closer to the real one.

b) In the existing methods, only the man-hours of key staff are considered in details. The cost of support staff and construction supervision cost are estimated by lump sum method. The man-hours of junior designers, site engineers, inspectors and CAD operators are not considered in details. In the activity breakdown method, all of required persons are considered so the total man-hours should be close to the real one.

c) In the existing methods, the estimation method cannot be used as a base plan for the project planning because all of items are estimated from the experiences of the estimator. There is not a relation between the activities and time shown to use as a guideline for a master plan. In the activities breakdown method, the puposed work schedule are made so it can be used as a base plan for the project planning.

d) In the existing methods, if there are a lot of competitors and the company would like to reduce cost, the estimator is not sure that how to reduce the cost. In the new method, the costs of all items are considered in details and based on the real activities so the estimators can consider each item to adjust the cost. He can reduce the cost with self-confidence that it is not lower than the real one.