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A CASE STUDY ON QUALITY MANAGEMENT SYSTEM IN CONSTRUCTION PROJECT

Mat Naim Abdullah
Saidin Misnan
Wan Yusof Wan Mahmood

INTRODUCTION

This chapter highlighted the results on the evaluation of the QMS implementation in the case project, Kuala Lumpur International Airport (KLIA). It first discussed the opinion of the experts gathered through a questionnaire regarding the propositions derived from the literature review. Then it followed with the discussion on the data collected from the PQP of the construction team and the interview of the key personnel involved in the case project. The data collection was based on the eight unit of analysis refined by the expert opinion from the propositions of the literature review. The data from the three sources was triangulated and a context diagram of each element was developed using the IDEF0 modelling technique.

EVALUATION AND DISCUSSION ON QMS IMPLEMENTATION IN KLIA PROJECT BASED ON PQP

One of the sources of evidence used for the study was PQP of the construction team. PQP is a document where a party has to submit to his client to demonstrate his commitment to complete a project

or contract in a manner that will satisfy the client's requirements or in quality term, the work had achieved the quality standard. Thus, PQP submitted by the parties involved in the KLIA project would be the right source to understand how QMS was implemented in the project.

Literature review had revealed that there were slight differences between the PQP of the construction team. In order to strengthen the literature findings, the researcher had analysed by comparing a set of the Project Manager's PQP, a set of the Consultant's PQP and a set of the Contractor's PQP for the KLIA project. The method of is known as content analysis technique and the results of the analysis are shown in Table 4.1.

Unit of analysis		Management responsibility	Quality planning	Resources management	Process control	Inspection and testing	Auditing	Quality recording	Data analysis and reporting
PQP Project Manager	Input	Contract documents	Quality policy, quality objectives and authority and responsibility of key position, summary of project information (cost, time, quality)	The work programme, cost programme, employment programmes	Temporary facilities and infrastructure, training schedule, work programme and cost programme	NR	PQP, inspection and test plan, other documented system	Audit, inspection and test, quality, Request for Inspection (RFI), financial, progress and management review reports, contract document, correspondence	Customer feedback, quality records, audit, progress, financial and quality report
	Mechanism	Steering committee, Senior Manager, Quality seminar and meetings	Planning software, cash flow technique, planner, quantity surveyor, quality manager, construction manager	Administration & Human Resource (HR) Manager, Quotation, Tender, Database, Trainer/ Consultant, quality recording	Quality Assurance (QA) personnel, trainer, training room, submittals forms, site meeting, construction manager	NR	QA personnel, head of department, contractor, consultant, audit plan, auditor	Document control centre (DCC), filing system, documentation system	Reporting system, management review

Unit of analysis		Management responsibility	Quality planning	Resources management	Process control	Inspection and testing	Auditing	Quality recording	Data analysis and reporting
	Control	Company policy, Company QMS	Company policy, company QMS, project budget, construction method, resources availability, summary of project information	Company policy, Company QMS, PQP, statutory	Work and cost programme, PQP, labour, material and plant programmes, method statement, inspection and test plan and audit plan.	NR	Audit procedure , audit plan, PQP	Document control procedure, contract agreement, statutory requirement	PQP
	Output	Quality policy, quality objectives, responsibility of key position, summary of project information (cost, time, quality)	The work programme, cost programme, PQP, and audit plan.	Employment agreement, temporary facilities and infrastructure and training schedule	Non-conformance report (NCR), site instruction	NR	NCR, preventive and corrective action, audit report	Quality records	Quality improvement and management review report, corrective and preventive actions

PQP Consultant	Input	Contract documents, Service agreement	Quality policy, quality objectives and authority and responsibility of key position, summary of service scope	The work programme, cost programme, employment programmes	Employment agreement, temporary facilities and infrastructure, data and quality records and training schedule	Sample review, material on/off site, in-process work, final works/product, design	PQP, inspection and test plan, other documented system	Audit, inspection and test, quality, RFI, progress report/minutes, contract document, correspondence	Customer feedback, quality records, audit reports, progress report, quality report
	Mechanism	Chief Resident Engineer, Seminar/meeting	Planning software, Planning engineer	Administration & HR Manager, Quotation, Tender, Database, quality recording	Value engineering, NCR system, site instruction, Resident Engineer, Request for inspection (RFI)	RFI, checklist, clerks of works, testing equipment and tools, laboratory	QA personnel, head of department, contractor, audit plan, auditor	Document control centre (DCC), filing system, documentation system	Management review

	Control	Company policy, Company QMS, statutory	Company policy, company QMS, project budget, construction method, resources availability, summary of project information	Company policy, Company QMS, PQP, statutory	Work programme, PQP, construction method statement, inspection and test plan and audit plan.	ITP, method statement, specification, drawings, engineering standard	Audit procedure, audit plan, PQP	Document control procedure, contract agreement, statutory requirement	PQP
	Output	Quality policy, authority and responsibility of key position, summary of service scope	The work programme, PQP, construction method statement, inspection and test plan (ITP) and audit plan.	Employment agreement, temporary facilities and infrastructure, and training schedule	NCR, construction product, site instruction	Quality report, NCR, site instruction, defect lists,	NCR, preventive and corrective action, audit report	Quality records	Quality review report

PQP Contractor	Input	Contract documents	Quality policy, quality objectives and responsibility of key position, summary of project information (cost, time, quality)	The work programme, cost programme, labour, material and plant programmes	Work and purchase order, supply agreement, contract agreement, skilled workers, temporary facilities and infrastructure	Sample review, material on/off site, in-process work, final works/product, design	PQP, inspection and test plan, other documented system	Audit, ITP, quality, RFI, financial, progress and management review reports, contract document, correspondence	Customer feedback, quality records, audit, progress, financial and quality report
	Mechanism	Project Manager, Quality seminar and meetings	Planning software, cash flow, planner, quantity surveyor, quality manager, construction manager	Administration & HR Manager, Quotation, Tender, Trainer/ Consultant, quality recording	Value engineering, corrective and preventive action, NCR, site instruction, site team and site meeting	RFI, checklist, supervisors, testing equipment and tools, laboratory	QA personnel, head of department, contractor, consultant, audit plan, auditor	Document control centre (DCC), filing system, documentation system	Reporting system, management review

	Control	Company policy, Company QMS, contract document	Company policy, company QMS, project budget, construction method, resources availability, contract document	Company policy, company QMS, PQP, statutory requirements	Work and cost programme, contract document, PQP, labour, material and plant programmes, method statement, ITP and audit plan	ITP, method statement, specification, drawings, engineering standard	Audit procedure, audit plan, PQP	Document control procedure, contract agreement, statutory requirement	PQP
	Output	Quality policy, quality objectives, responsibility of key position, summary of project information (cost, time, quality)	Work and cost programme, PQP, labour, material and plant programmes, construction method statement, ITP and audit plan.	Work and purchase order, supply agreement, contract agreement, skilled workers, temporary facilities and infrastructure, training schedule	NCR, construction product, site instruction, site diary, progress report	Quality report, NCR, site instruction, defect lists,	NCR, preventive and corrective action, audit report	Quality records	Quality improvement and management review report, corrective and preventive actions

Table 4.1: Content analysis of PQP of the construction team

The table shows that the difference between the content of the Project Manager's, Consultant and Contractor's PQP can be ignored. One of the problems in collecting information and data from PQP is the difficulty to relate between one element and process to another. The information in the PQP were arranged according to functional hierarchy rather than process oriented. Thus to trace the relationship was not an easy task and therefore it was not included in the discussion. The following section described the findings.

MANAGEMENT RESPONSIBILITY

This element is addressed by all parties in their PQP and the inputs, constraints and outputs are also relatively similar. The difference is in addressing the mechanism for driving and implementing the element. While the Project Manager rely on the their steering committee and senior managers to identify the contract requirements, setting up the quality policy and objectives, delegating the responsibilities and disseminating the information through seminar, briefing, meeting etc., the consultant address their chief resident engineer as the person in charge to take the management responsibility on the successful implementation of the PQP. Meanwhile the contractor named its own Project Manager as person in charge.

The findings of the content analysis on the element of management responsibility are summarised as follows;

Input: Contract document
Mechanism: Senior managers, chief resident engineer, project manager, meeting
Constraints: Company policy, company QMS, statutory, contract document

Output: Quality policy, quality objectives, responsibility of key position, summary of project information in term of cost, time and quality or service scope.

The main input from the PQP is the contract document and this is expected as the main document to be referred to before developing the project quality policy and objectives. A similar group of drivers i.e. senior managers indicated in the propositions are also indicated in PQP. However the PQP is more specific in delegating the roles to a specific position such as the Project Manager for the Client's representative, the Chief Resident Engineer for the Consultant and the Construction Manager for the Contractor.

QUALITY PLANNING

All parties devise the activity of this element based on the output of the management responsibility. The constraint, mechanism and output for this element are also relatively similar for all parties except for the Contractor where they have to produce the Inspection and Test Plan (ITP) and the Method Statement. The findings of the content analysis on the element of quality planning are summarised as follows;

Input: Quality policy, quality objectives and responsibility of key position, summary of project information.

Mechanism: Planning software, projected cash flow diagram, planner, quantity surveyor, quality manager, construction manager.

Constraints: Company policy, company QMS, project budget, construction method, resources availability, contract document.

Output: Work and cost programme, PQP, labour, material and plant programmes, construction method statement, ITP and audit plan.

However, again the PQP give more information on the tasks of the specific parties such as the Quantity Surveyor is responsible for the development of cost programme and the inspection and test plan is prepared by the Contractor but approved by the Consultant.

RESOURCES MANAGEMENT

The input, constraint, mechanism and output for this element are comparatively similar even though some of the documents bear different name such as tender and work or purchase order. The findings of the content analysis on the element of resources management are summarised as follows;

Input: The work programme, cost programme, labour, material and plant programmes .

Mechanism: Administration & HR manager, quotation, tender, trainer/ consultant, quality record .

Constraints: PQP, contractual specification, statutory requirement.

Output: Work and purchase order, employment agreement, supply agreement, contract agreement, skilled workers, temporary facilities and infra-structure, and training schedule.

The above finding shows that the PQP provides more information on the specific tasks of the construction team. The significant feature identified through the PQP is the hierarchy of the flow of information and documents. The flow is in the following sequence; prepare by the Contractor and then review and approve by Consultant and then review and verify by the Project Manager. The approval is by the Consultant as he is the designer of the project.

PROCESS CONTROL

All parties indicate that the output of the elements of quality planning and resources management are the input for the process control such as work programme, cost programme etc. The constraints and mechanism are relatively similar with the ITP as an extra control document for the Consultant and Contractor. However this element reflects the functions of each party such as the Project Manager for managing the project, the Consultant for designing and supervising the implementation and the Contractor for implementing the construction works, thus, the output of each party for this element are different such as summary of progress, quality and financial status of the work for Project Manager, NCR and quality control report for Consultant and detail progress report for the Contractor. The findings of the content analysis on the element of process control are summarised as follows;

Input:	Work and purchase order, supply agreement, contract agreement, skilled workers, temporary facilities and infra-structure .
Mechanism:	Value engineering, corrective and preventive action, NCR, site instruction, site team and site meeting .
Constraints:	Work and cost programme, contract document, PQP, labour, material and plant programmes, method statement, ITP, audit plan.
Output:	NCR, construction product, site instruction, site diary, progress report.

The PQP is more detail and specific in addressing the documents such as work and purchase order as basis for checking the incoming materials, value engineering for assessing the viability of the material or construction method and NCR for monitoring the quality of the workmanship and materials. The output also is more precise such as the progress report and site diary to record the site activities.

AUDITING

This element was addressed by all parties in their PQP. However, the Project Manager roles in external auditing was to audit the performance of Consultant in undertaking their tasks in order to ensure the tasks were in accordance with the statements of requirements provide by the Project Manager. Similarly the Consultant will audit the Contractors' performance against the minimum requirements provide by the Project Manager such as prepare and submit the ITP. All these minimum requirements were also stated in their PQP. Therefore the audit was carried out to check the adequacy and compliance on the PQP according to the audit plan. The result is an audit report with the NCR issued for the non-compliance. This NCR should be closed by implementing the preventive or corrective action.

The findings of the content analysis on the element of process control are summarised as follows;

Input: PQP, inspection and test plan, other documented system.
Mechanism: QA personnel, head of department, contractor, consultant, audit plan, auditor.
Constraints: Audit procedure, audit plan, PQP.
Output: NCR, preventive and corrective action, audit report.

INSPECTION AND TESTING

The incoming materials, in process and final inspection were carried out by the Consultant based on the approved ITP. The ITP consisted of the method statement, inspection checklist and specification and drawings for the inspection area. In contractors' PQP, Request for Inspection (RFI) procedure and form was included as a means to fix the actual date for inspection and to record the inspection result. The Consultant will perform the inspection on the date either by observation or testing. The

outcome of the elements is a quality report that summarized the inspection and test result, including the test records, site instruction, NCR and in case of final inspection, the defect lists. The Project Manager did not include this element in their PQP as their role relating to this element was to ensure the consultants perform the activities. Even though part of the inspection and testing activity was to inspect the incoming materials, the selection of materials to be used was done under the element of resource management.

The above findings for the element are summarized according to IDEFO format as follows:

Input: Sample review, material on/off site, in-process work, final works/product.
Mechanism: RFI, checklist, supervisors, testing equipment and tools, laboratory.
Constraints: ITP, method statement, specification, drawings, engineering standard.
Output: Quality report, NCR, site instruction, defect lists.

QUALITY RECORDING

This element also has been addressed by all parties in their PQP. The inputs are depending on the functions of each party such as RFI by the Contractor, test records by the Consultant and the financial and progress report by the Project Manager. However, certain records are similar such as audit report that is kept by the Project Manager and the Consultant. The mechanism, constraint and output of this element indicated by all parties are relatively identical.

The findings of the analysis on the element are summarized as follows:

Input: Audit, ITP, quality, RFI, financial, progress and management review reports, contract document, correspondence.
Mechanism: Document control centre (DCC), filing system, documentation system
Constraints: Document control procedure, contract agreement, statutory requirement.
Output: Quality records.

The element is considered important as some of the documents are required by the contract such as site diary, testing and commissioning records and operation and maintenance manual.

DATA ANALYSIS AND REPORTING

This element has been addressed adequately by all parties. It is a requirement by the ISO 9000 to allow for system improvement. The input, constraint, mechanism and output of this element stated by all parties in their PQP are relatively identical. The above findings for the element are summarized according to IDEFO format as follows:

Input: Customer feedback, quality records, audit, progress, financial and quality report.
Mechanism: Reporting system, QMS review.
Constraints: PQP.
Output: Quality improvement and management review report, corrective and preventive actions.

EVALUATION AND DISCUSSION ON QMS IMPLEMENTATION IN KLIA PROJECT BASED ON INTERVIEW

Another source of evidence used to collect data from the case study was by interviewing the key personnel involved in the QMS implementation at KLIA project. The key personnel identified was the General Manager and Senior Manager of QA and Planning Department of Project Management Company i.e. KLIAB.

As the Project Manager of the KLIA project, KLIAB played a crucial role to ensure successful implementation of QMS. Thus, every aspect of the construction processes should be taken into consideration and procedures shall be established to ensure quality is achieved throughout the processes. This factor and the situation where the consultants and contractors were not normally on site after the project completed led to the information gathered merely from KLIAB.

To avoid the tendency of gathering voluminous but insignificant information, the researcher had identified through the literature review, the unit of analysis i.e. management responsibility, quality planning, resources management, process control, inspection and testing, quality recording, auditing and data analysis and reporting, where a set of interview questions had been developed accordingly. The detail of the interview questions are attached in Appendix B. The outcomes of the interview are discussed below.

MANAGEMENT RESPONSIBILITIES

The top management of KLIAB realised that they must become the motivators and key players to support the QMS implementation processes. They also realised that they must ensure all level of management, consultants, contractors and even workers to understand, support, implement, maintain and improve the system so as to achieve their corporate objectives.

Their first task was to convince themselves that the concept of QMS could bring tremendous impact on their business success or otherwise the earnest commitment to implement and sustain the system was nearly impossible. Through the induction course, seminars and a series of consultation, the top management were satisfied that QMS embracing the philosophies of ISO 9000 standards could maintain and improve the quality of the company's services to achieve customer's satisfaction. In fact, the commitment of the top management of KLIAB was the driver of the successful implementation of the QMS in view of the normal resistance towards new idea from either the consultants or the contractors or even the KLIAB's staffs.

To unite and integrate the understanding and effort of the construction team, the KLIAB's top management had established clear goals by referring to the government's requirements of the KLIA project defined in the contract document and any statutory requirements. These goals became the KLIAB's corporate objectives that related to the construction period, cost and specifications. The objectives also became the main input to the project and cost programmes.

To achieve the objectives the top management had incorporated them into the quality policy. With the statement on the quality policy saying that, "KLIAB believes Quality Excellence shall spearhead the Company to achieve its Corporate Mission: To

develop a leading regional hub airport that will join the ranks of front-runners in the world of aviation", reinforced the belief and commitment of the top management of the QMS. The top management also believed that by incorporating the objectives into the company QMS the correct mechanism had been used to ensure the corporate missions being accepted and understood by the construction team.

The top management had also selected the competent senior managers for the challenging task to lead in the implementation of the QMS within their divisions. They were considered as the strategic level of management where the successful of the QMS implementation were also rested on their shoulders. The top management had to clearly convey the corporate mission to the senior managers and convince them on the positive influence of the QMS against the achievement of the mission. These messages were continuously repeated and reminded during the scheduled management meeting. The Managing Director had delegated his authorities for maintaining the QMS, establishing and maintaining the system of preventive and corrective and ensuring the timely and effective action was taken by appropriate staff to maintain the integrity of the QMS. Nevertheless, the responsibilities to develop, implement and maintain the procedures rested with the General Manager of the specific division.

With the assistance of the quality consultants and facilitation and co-ordination from the Quality Manager, the quality manual and procedures were developed according to the quality policy by the designated team of each division led by its General Manager. No gap analysis was carried out to assess current position and to determine the shortfalls of KLIAB as the company was newly established specifically to manage the KLIA project. However, all senior managers of KLIAB had a wide experience in managing construction projects and well versed with the construction processes, statutory requirements and contract specifications and

standards, making the process of documentation uncomplicated and practical.

QUALITY PLANNING

KLIAB had divided the KLIA project into 187 contracts packages. There were also 110 parties involved and KLIAB had identified more than 1600 interfaces needed to be managed carefully in order to avoid disruption to the progress of the construction works. Considering the amount of information (drawings, specifications, procedures, contract details), parties and the number of interfaces, the importance and criticality of effective communication cannot possibly be overemphasized. The most important was to ensure all parties were working towards similar goals that had been incorporated in the KLIAB's Quality Policy.

To ensure unity in all aspects of activities and the specific construction works were under control especially the communication and dissemination of right information, all parties were required to prepare specific quality plan for their works. The document was called Project Quality Plan (PQP). The contractors and consultants had no reason to ignore the requirement as it was stipulated in the tender document. To tie or integrate the individual party's PQP into one project quality system KLIAB set the system as shown in Figure 4.1 below

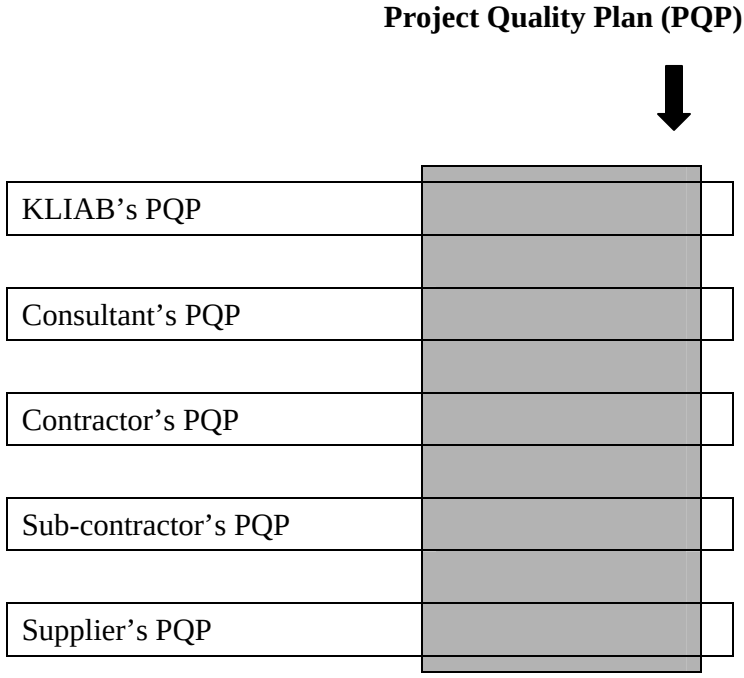


Figure 4.1: The integrated PQP of KLIA project

KLIAB developed its PQP first and KLIAB's PQP was in fact similar to its Quality Manual. One of the content of KLIAB's PQP was a set of information that the consultants and contractors had to include in their PQP. Base on this information or requirements, consultants and contractors then developed their PQP. To develop the PQP, other information was also required such as the project scope and quality requirements that stated in the contract document and resources availability. In the preparation of the PQP the parties also took into consideration of the ISO 9000 quality standard as it was the existing quality standard available in market, KLIAB's

Quality Manual, master work programme, contractual specification and any relevant statutory requirements.

The content of the PQP in general regardless of the discipline of the parties involved in the construction works were the description of the project and the scope of work, project organisation chart including responsibility and authority distribution and identification of external and internal lines of communication, reference to all applicable and related documents, procedures, instructions, documents etc. A detailed activity programme including any interface, identification of operational procedures to be used for the project, list of any special submissions and/or approvals, a schedule of quality control audits to be carried out and a schedule of quality systems audits to be carried out to check compliance with quality system standard requirements were also included in the PQP. Others were related to the storage and retrieval of records such as the list of all project documents and records produced, definition of archive storage arrangement including the storage mediums as well as the retention periods. Any other key information or requirements considered being important for the management of the project as well as for quality management and control purposes such as inspection and testing plan is also included.

To ensure the control of the PQP regarding the punctuality of the submission and the appropriate content, KLIAB had set up a system as shown in Figure 4.2. According to the system, KLIAB's Quality Manual and Procedures shall be the key document to be referred but the monitoring and controlling of the individual PQP were relied on the superior party. In this instance, the contractors submitted their PQP to the concerned consultants and the consultants' PQP were submitted to KLIAB. The consultants carried out the compliance audit on the contractors' PQP. The consultants' PQP were audited by KLIAB.

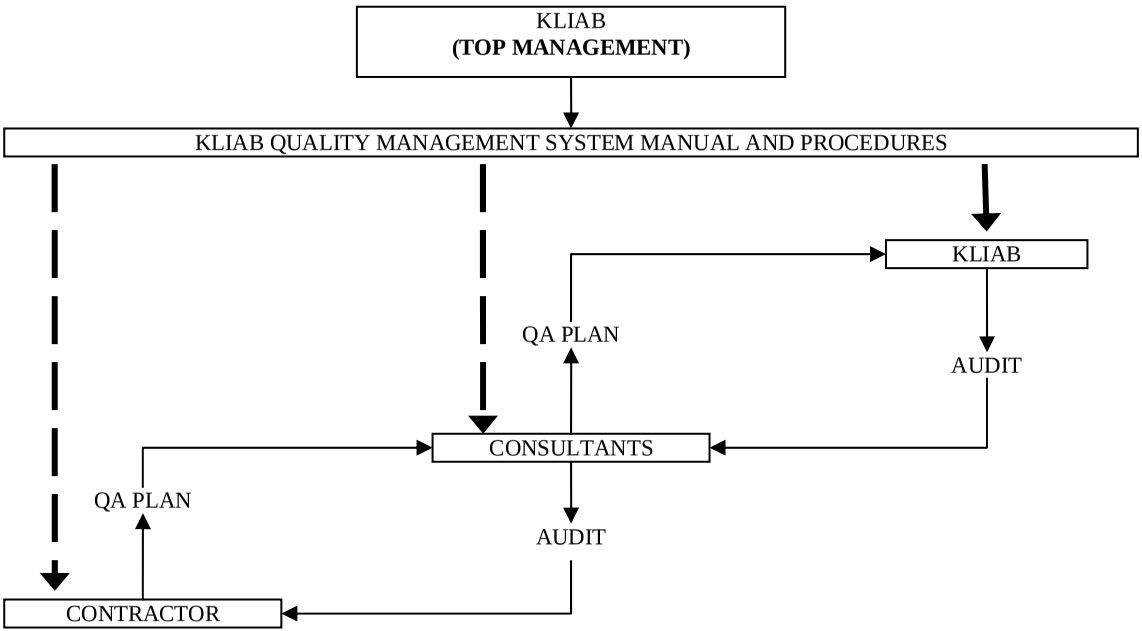


Figure 4.2: KLIAB Quality Management System

RESOURCES MANAGEMENT

By analysing the company's capabilities and the project requirements, the main resources that the company prioritised as necessary for the implementation of the QMS were organisational structure and employee development. As this project was a national main agenda, fund was not a big issue.

ORGANISATIONAL STRUCTURE

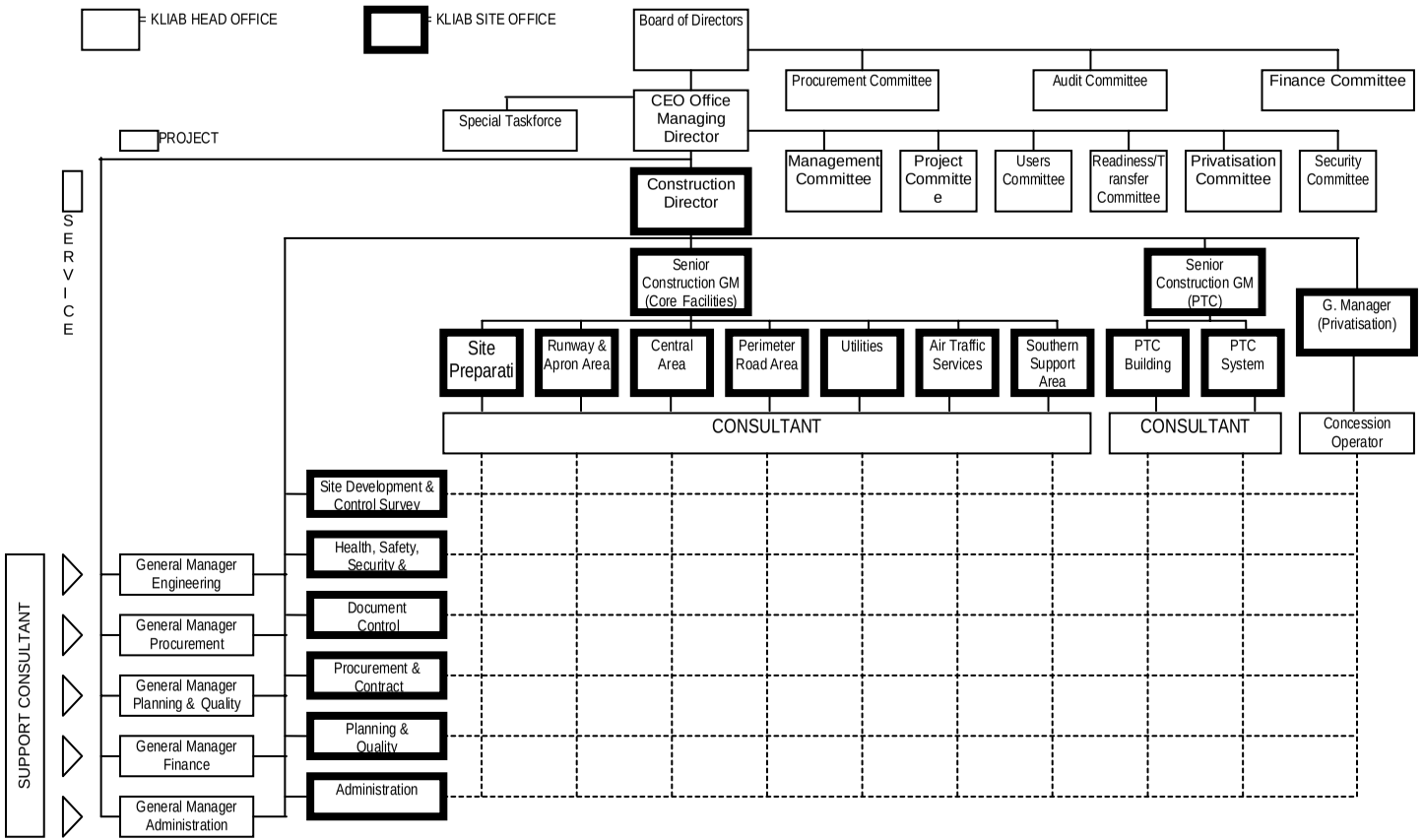
KLIAB had chosen the matrix structure for their organisation. Figure 4.3 shows the matrix structure of KLIAB. This structure was appropriate to be utilised in line with the QMS and the mega size of the KLIA project. It stressed on the importance of check and balance between the operation and strategic level. Suitable to adapt the concept of QMS, it cultivated open style of management naturally and allowed improvement programme to be implemented.

KLIAB's organisational structure was designed carefully in tandem with the company's mission and the project requirements. It was divided into the service unit that illustrated horizontally and the project unit that illustrated vertically. The service unit was classified according to its functions and the project unit was classified according to the type of projects. This had allowed KLIAB to make amendments easily in line with time and project requirements, as the structure was flexible.

A set of minimum functions of each service and project divisions was designed consistent with the organisational structure. The functions were derived from the contract requirements, the KLIAB's Quality Manual and any related statutory requirements in order to ensure all related aspects of KLIA development were not

missing. The functions of each division then became the responsibilities and authorities of each head of divisions and departments. These lines of responsibilities and authorities were stated clearly in the KLIAB's PQP.

Figure 4.3: Matrix Organisation Structure of KLIAB



EMPLOYEE DEVELOPMENT

The employee development had started prior to the process of documenting the manual and procedures. To ensure support from the employees regarding the implementation of QMS KLIAB believed that they must be invited to involve in the documentation process. However, understanding and awareness of the system must be developed prior to the documentation process. Therefore, KLIAB had conducted several seminars and official and unofficial special meeting with regard to the QMS such as introduction to QMS, understanding the KLIAB's organisational structure and the documentation process. Such seminars were also given to the supervisory consultants and contractors as KLIAB realised that QMS was relatively new to the construction industry in Malaysia, hence, they were not fully understood the requirements.

The understanding, awareness and capability of the employees and the related parties in regard to the implementation of QMS were assessed continuously by the Planning and Quality Assurance Division. It identified the training needs for sustaining the QMS. Advanced training courses such as Effective Implementation of KLIAB's QMS, Quality Planning in Construction, Internal Quality Auditing, Second Party Audit and Process Improvement Programme were recognised as necessary and conducted for all level of management.

KLIAB also stressed on the capabilities and skills of its personnel in undertaking the highly technical works of KLIA project. KLIAB had imposed stringent criteria in selecting its personnel. The criteria of the required post were specified in the relevant document kept by the Administration Division. Working experiences and speciality together with the skill in managing people were among the criteria.

PROCESS CONTROL

KLIAB had identified two main activities of process control that related to its function under the KLIA QMS. They were control of purchased services and inspection and testing. Due to its major function in the whole of construction process inspection and testing activity was dealt under separate section. Both activities were depended on the prior activities such as management review, quality planning and resources management. The outputs of these activities were the inputs of the control of the construction processes. Work and cost programmes and PQP were among key documents or information.

The quality of construction is much depended on the quality of the materials, workmanship and the right choice of equipments to be used. Because these factors remained on the contractors and the expertise of the supervisory consultants, the selection of the right companies to undertake the work is very crucial. This was the main activity under the construction processes with regard of KLIAB function. The consultants and contractors were selected through strict processes and procedures of either selective tendering or pre-qualification. Job references and experiences together with the proposed contract price and fees were among the main conditions. Scheduled evaluations on their performances were carried out and reported to the top management of KLIAB for further actions. In some cases stern measure had to be taken such as expelling them from the project.

To ensure the project was on track according to the work programme, cost and specification, progress meetings were carried out periodically. The meeting discussed the actual progress of works comparing to the schedule. Any causes of delay or variations were highlighted and corrective and preventive measures were discussed and to be implemented by the concerned parties. Future expected problems that can cause delay or variation and any preventive measures were also discussed. Controlling works according to

specification were mainly carried out at site under the inspection and testing. Only major problems regarding sub-standard works were discussed in the periodically progress meeting.

AUDITING

KLIAB realised that documentation alone was not enough to ensure the plan will be implemented. Even the punctuation of the submission of the PQP was not run smoothly and due to lack of understanding of and retaliation to the implementation of QMS all quality-related activities were not properly documented, understood and carried out accordingly. To reduce the problems KLIAB stressed on auditing that served as a measure to countercheck all parties' understanding and activities so that they were all heading towards the one similar 'destination'.

The auditing system in KLIA is as shown in Figure 4.2. Two ways of audit were practiced in KLIAB audit system. The first was internal quality audit and the second was second party audit or external audit.

IQA involved auditing within an individual organisation such as KLIAB. Two kinds of audit called Adequacy and Compliance Audit were conducted and mostly by the Planning and Quality Assurance Division. The auditor audited the procedures developed by a division to ensure adequacy of the documentation works. After a certain period and according to the audit plan the auditor audited the performance of the division in term of compliance against the documented procedures. Any non-conformance requirements (NCR) were identified and then classified according to major or minor NCR. All these were included in the audit report along with any recommendations for corrective or preventive actions to be taken by the audited party.

All parties involved in the KLIA project were required to prepare and submit the PQP to the concerned parties. The adequacy of the document and the compliance to the documented procedures were

examined during the Second Party Audit. The same auditing processes during the IQA were repeated for SPA.

INSPECTION AND TESTING

This activity is actually a part of process control activity. The aim of the inspection and testing is to ensure the final product is according to the specification. But because the quality of the product is depended on the quality of the process of making the product, therefore the inspection and testing in KLIA project was divided into three stages namely receiving, in-process and final. The inspection and testing were carried out according to the inspection and test plan that form part of the PQP.

As it was a part of PQP, the inspection and testing plan had been developed prior to the construction works. The inspection and testing points were identified by the consultants and contractors based on the work programmes and method statements of the special works. In KLIA project the responsibility to carry out inspection and testing had been delegated by KLIAB to the supervisory consultants as they had the speciality in certain areas of works. KLIAB's task in regard to inspection and testing was to ensure the supervisory consultants performed the inspection and testing according to the inspection and testing plan. Nevertheless, the contractors were also involved and performed their own inspection and testing especially related to sub-contractors works and materials supplied by the suppliers. They were also responsible to performed joint inspection and testing with the supervisory consultants for any works or materials that had been included in their inspection and testing plan. All inspection and testing activities were audited for their regularities and timely.

Receiving inspection and testing were performed to ensure raw materials supplied by the supplier were according to the contract

document in term of specification and quantity. In some special works, inspection and testing was carried out to ensure the preparation works were according to the method statements. On-going process inspection and testing were implemented during the construction works such as for the concrete slump and cube test. Finally, the final inspection and testing was performed to the product or works such as on the finishes whether it is to the satisfaction of the owner and to the electrical work whether it functions properly and safely. All testing and inspection results were recorded and the records were kept by Document Control Centre.

Any irregularities and sub-standard materials and workmanships identified during the inspection and testing were investigated to identify the root causes. Corrective actions normally were done immediately after the problems detected and preventive actions were discussed during the progress meeting and any related decisions were implemented during the construction works.

QUALITY RECORDING

Another major activity identified by KLIAB in order to ensure successful implementation of QMS was quality recording. KLIAB had identified the sub-activities of quality recording such as process of identification, collection, indexing, access, filing, storage, maintenance and disposition of quality records. Documented procedures for the processes were developed and maintained. The aims for this activity were to maintain and demonstrate conformance to specified requirements and the effective operation of the QMS and to provide accurate information for data analysis in supporting continuous improvement activity.

KLIAB also identified the significant quality records for its own, consultants and contractors recording activities. They were based on the ISO 9000 requirements with slight changes to suit the construction environment. Among the quality records were as follows:

- Management reviews.
- Contract documents.
- Tender drawings including design input data, output data, reviews, verification, validation and changes.
- Contract drawings including design input data, output data, reviews, verification, validation and changes.
- Project quality plan (PQP).
- Inspection and testing plan.
- Method statements for special works.
- Construction drawings including design input data, output data, reviews, verification, validation and changes.
- Architect's/Engineer's Instructions.
- Purchase orders.
- Contractors/Consultants records.
- Records of customer supplied products.
- Equipment calibration and maintenance records.
- Inspection records.
- Test reports.
- Material delivery records.
- Progress reports.
- Preventive and corrective action records.
- Minutes of progress meeting.
- Internal and second party audit reports.
- Employee qualification records.
- Training records.
- Service records.
- Data analysis reports.

DATA ANALYSIS AND REPORTING

The success of QMS is not solely depending on the success of documenting the manual and procedures. Instead, it demands continuous assessment on the performance of the QMS implementation. Realising this factor, KLIAB introduced the activity of data analysis and reporting system to have reliable information that very significant in supporting the decision making process.

A documented procedure was established and maintained to implement and control the application of data analysis and reporting system. Based on the identified quality records, the data were analysed using several established techniques such as Statistical Process Control (SPC) and benchmarking. The results along with suggestions whether to maintain, abolish, amend, or improve any procedure or even to introduce new procedure were then reported to the top management for review. The endorsed decision by the top management was forwarded to the designated department to implement it.