QUALITY CONTROL AND QUALITY ASSURANCE OF SUBSURFACE DRAINAGE PROJECTS IN EGYPT

Gehan A. H. Sallam.

Drainage Research Institute (DRI), National Water Research Center (NWRC),
El Kanater, Cairo - P.O. Box 13621/5, EGYPT. (E-mail: Gehanhakeem@hotmail.com)

ABSTRACT

A subsurface drainage system has to function properly over a long period. Therefore it must be accurately and properly installed. There are currently about 470,000 feddans of land with pipe drainage in Egypt, approximately 11% of the total drained area, which are not functioning properly. The poor quality of subsurface drainage construction is due to several reasons, including: damaged pipe materials, poor pipe connections, misalignment and depth fluctuations of collectors and laterals during installation, pipe sedimentation, and lack of envelope. A quality control and quality assurance system for subsurface drainage projects was developed to improve their quality. A questionnaire was conducted within Egyptian Public Authority for Drainage Project (EPADP) to analyze the current construction practices and the main phases of the project. The main phases analyzed here are Field Investigation phase, Design phase and Tendering and Construction phase. The specifications and standards of each phase and the main control points were determined. A linear responsibility matrix was developed for each phase. After that, the weakness points and the required corrective actions were also determined for each phase. The results showed that, the low quality of subsurface drainage system construction is attributed to the lack of adequate aspects of quality control and quality assurance for the phases of the project. To improve the quality control and quality assurance for the project, it is important to concentrate on the main control points of each phase and apply the required corrective actions.

Keywords: Quality assurance, Quality control, Quality system, Subsurface drainage system.

INTRODUCTION

The Nile Delta and the Nile valley of Egypt, is one of the oldest agricultural areas in the world, having been under continuous cultivation for at least 5000 years. The Delta of the Nile is now one of the most fertile and intensively cultivated regions in the world, due to the Nile mud brought down by the Nile from the Ethiopian plateau. The agricultural sector accounts for more than 30% of the gross national product (Abu-Zeid, 1990). At the turn of the 19^{th} century, perennial irrigation was introduced in the Nile River Delta and Valley of Egypt. This lead to raise groundwater table, and increase problems of water logging and salinity. As a consequent result of these problems the productivity of the agricultural land decreased. If subsurface drainage is not provided, when needed, the crop yield will be reduced by as much as 20 percent in a very few years. It would be uneconomical to cultivate land with this reduced productivity (Johnston, 1976). In response to this challenge, the government gave high priority for installing drainage systems.

In Egypt, it is estimated that up to 1995, approximately 4.3 million Feddans (1 Feddan = 0.42ha) have so far been subsurface drained and another 2.1 million Feddans will be implemented between 1996 and 2010 (Advisory Panel on Land Drainage, 1996). One of the main advantages of constructing subsurface drainage system in the Nile Delta is increasing the productivity of crops actually by 138%, 48%, 75% and 10% for Wheat, Berseem, Maize and Rice respectively (Abdel-Dayem et al, 1990). As part of the National Drainage Program, over US $ 35 million are to be spent on the rehabilitation of drainage systems. According to the performance indicators and measurements by the Drainage Research Institute (DRI, 1993) in selected areas, it was shown that the low quality of construction and lack of adequate inspection and supervision are the major reasons for system failure. It is expected that if proper attention is paid to quality control and quality assurance in drainage construction, then the maintenance cost and need for renewal is minimum. The quality control and quality assurance system is the organizational structure, responsibilities, procedures, processes and resources for implementing quality management. The quality system has to control what is produced to make sure it meets the requirements of the client and, secondly, it has to provide confidence or assurance is needed by both the contractor and the client (Ashford, 1989). In this paper Quality Control and Quality Assurance system for subsurface drainage project is developed.

STUDY METHODOLOGY

Effective quality management of a project requires a considerable background of information. The nature of this study requires a study base in a construction engineering and management to evaluate the quality control and quality assurance system of subsurface drainage projects in Egypt. It also needs knowledge of new ideas and approaches about the quality management systems. Then discuss problems, ideas, and proposed approaches with many concerned people. This should be done through interviews and questionnaires. Therefore, the study approach (*Figure 1*) includes analyzing subsurface drainage project to define its specification and the main control points. Then, define the weakness points and the main reasons of problems and consequently, determine the required improving and corrective actions.

To accomplish the study objectives, a questionnaire was prepared about the steps and arrangements followed in the field investigation, design and construction of the subsurface drainage projects. This questionnaire was accomplished within the Egyptian Public Authority for Drainage Project (EPADP), which is responsible for the design, and implementation of all drainage works, as well as for maintaining field drainage systems in Egypt. The main aim of the questionnaire is to get the views of the involved engineers in the current techniques of project construction and their recommendations to improve its quality. The questionnaire consists of two parts. The first part is concerned with the investigation and design phases. It is distributed through the Field Investigation and Research Department (FIRD) of the EPADP. The second part is concerned with the construction phase of the subsurface drainage works. It is divided into two subparts, the first subpart for the engineers of the EPADP who are responsible for the supervision of the construction of the projects. The second subpart for the engineers of the contractors who are responsible for the construction of the subsurface drainage works.

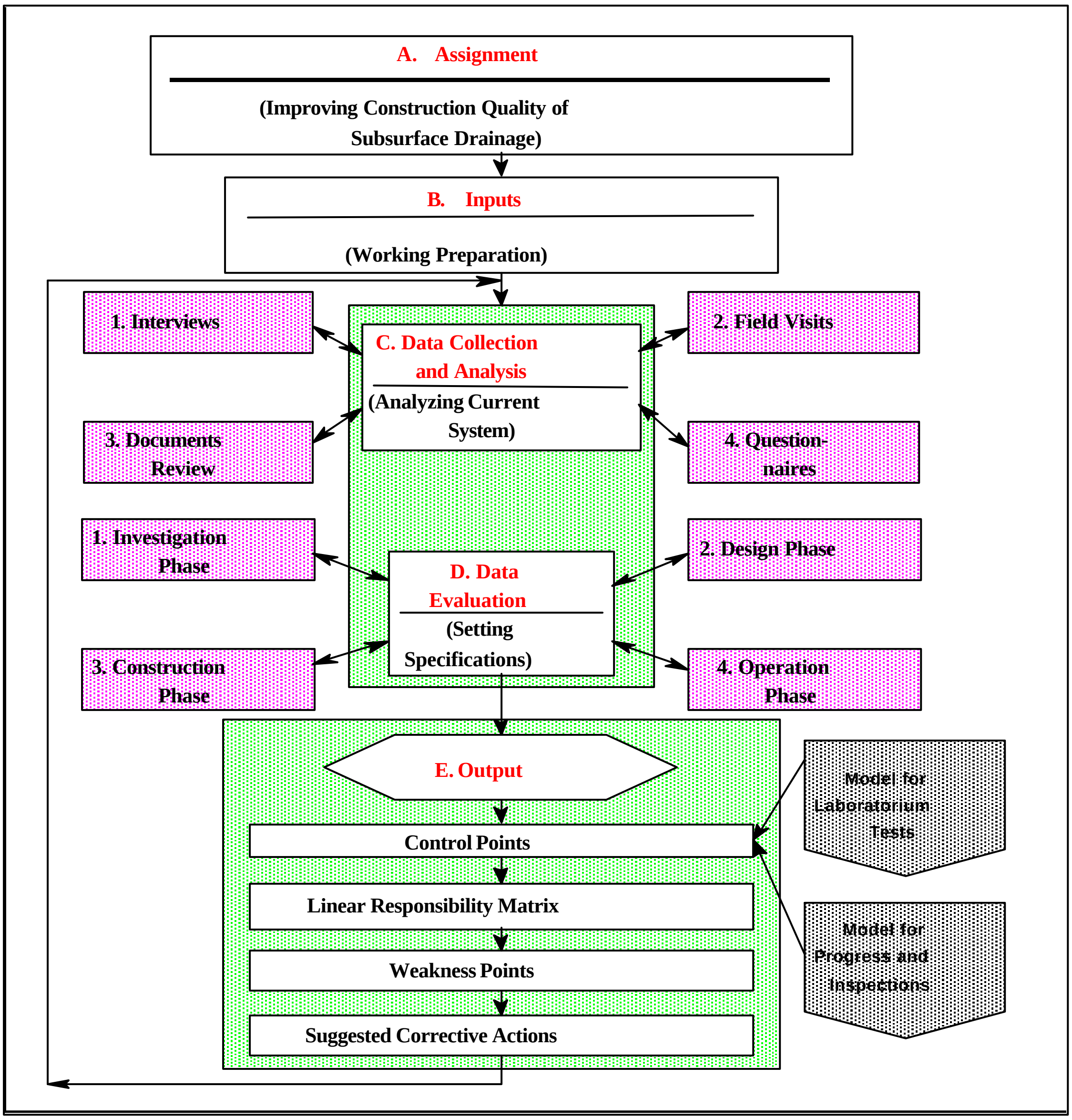

Figure 1 Study Methodology

RESULTS AND DISCUSSIONS

Each phase was divided to its main activities. The field investigation phase was divided to three main activities. They were defined as Preparing Maps, Fieldwork, and Processing of the Field Investigation Data. The design phase was divided to two activities as following: Determination of the layout and Design of the system. Tendering and construction phase was divided also to two main activities as following: Tendering process, and Construction work.

The main components of each activity were classified as Material, Planning, and Processing. After that, the specification and standards of each element were set. The control points of each activity were determined and evaluated. The control method was defined for each control points. This was done according to the data collected from the questionnaire. The main weakness points related to the control points were defined and the required corrective actions were determined.

The specifications and control points of the field investigation phase activities are shown in tables (1, 2 and 3) respectively.

Table 1: Specifications and Control Points of Preparing Maps Activity

Activity	Description and Specifications	Control Points	Control method	E
Material Field work maps	Map scale 1:25000 or 1:10000 with contour lines and spot levels from Survey Authority.			
Planning – Update of maps	Update of the maps according to the information of EPADP Directorates.	*	Inspect.	0
Processing – Provide maps with grid system	Grid system with grid width of 500 m.			
– Make the lay-out of canals and drains	A topographical map 1:25000 is made with the layout of canals and drains.	*	Inspect.	1
- Make cross sections of drains and canals	Make cross sections of drains and canals and their water levels and direction of water flow.	*	Inspect.	1

*: Control Point E: Evaluation 1: Under control 0: Need more control

Table 2: Specifications and Control Points of Fieldwork Activity

Activity	Description and Specifications	Control Points	Control method	E
Material – K Equipment - EC meter & plastic bags	1 auger, 1 stopwatch, 1 tape. To measure electrical conductivity and store soil samples.			
Planning – Provide maps with grid points - Arrange manpower and equipment for field work	Maps are provided with a 500m grid, one grid covers 60 feddan. The field group consists of one engineer, one observer and two workmen for approx. 5000 feddan.	*	Inspect.	1
Processing – Making leveling for ground surface	The ground elevation must be checked during the fieldwork.	*	Inspect.	0
– measurements at each grid point	Measure the ground water salinity and the ground water table.	*	Inspect.	1
– Measuring hydraulic conductivity (K)	At each grid point, an auger hole is made to 2 m depth to m	*	Inspect.	0
- Taking disturbed soil samples	easure K. At 0.2 and 0.5m below soil surface, samples are taken.	*	Inspect.	1

*: Control Point E: Evaluation 1: Under Control 0: Need more control

Table 3: Specifications and Control Points of Processing of Field Investigation Data

Activity	Description and Specifications	Control Points	Control method	E
Material - Field measurements data and soil samples	Include ground water table, salinity, K and soil samples at each grid point.	*	Inspect.	1
Planning - Sending soil samples to the laboratory	The soil samples are stored out by the engineer and sent to the laboratory.			
Processing – Analyze soil samples – Store the data - Drawing field data	EC, pH, water ESP and soil texture. Collected data is stored in the computer. The assistant design engineer draws the field data on 1:25000 map.	*	Inspect.	0

The suggested corrective actions for the field investigation phase were determined in relation to the control points and according to the national and international experiences and approved with the experiences that collected through the questionnaire as following:

1- Old field investigation maps: The maps must be updated according to the information of the directorates of EPADP. Obstacles must be recorded during the investigation work.
2- Need for make leveling for the project area: The project area must be leveled before design work to determine optimum layout and avoid any suddenly changes during implementation.
3- The insufficient measurements of hydraulic conductivity: The number of grid points must be increased to one boring for every 40 feddan to increase the reliability of collected data. It is also recommended to make the permeability tests for different depths in case of variability with depth.
4- Delay of the laboratory analysis: The laboratories must be increased and provided with the required-trained personnel.

The specifications and control points of the design phase activities are shown in tables (4 and 5) respectively.

Table 4: Specifications and Control Points of Determination of Layout Activity

Activity	Description and Specifications	Control Points	Control method	E
Material Maps of design work	Map scale 1:10000 and 1:2500.	*	Inspect.	1
Planning Design group is defined for each area	Design group is appointed by general director, inspector and supervisors.	*	Inspect.	0
Preparing cross section of open drains	Made by draftmen and compared with the original information of the Directorates.	*	Inspect.	1
Processing Determination of lay- out and drawing it	Design engineers work to finish the layout that contains several collector systems.	*	Inspect.	1

*: Control Point E: Evaluation 1: Under control 0: Need more control

Table 5: Specifications and Control Points of system design Activity

Activity	Description and Specifications	Control Points	Control method	E
Material				
Maps for design	Maps 1:10000, 1:25000& 1:2500			
Field data	All field data required for design work.	*	Inspect.	1
laboratory data	Laboratory result of samples.	*	Inspect.	0
Planning				
Printing maps	Maps to facilitate determination of lay-out and complete collector system			
Processing				
Compute geometrical average of drain spacing	Using the values of drain spacing of grid points that are situated in collector area.	*	Inspect.	1
Compute collectors profile	Computation is done by the computer.			
Determine envelope need	According to result of lab. analysis of soil texture.	*	Inspect.	0
Make draft draws on 1:2500 map	Make draft of complete collector system including laterals.	*	Inspect.	0
Filling in list of quantities	Use layout and longitudinal profiles to fill in the list.			
Make an overview map of 1:25000 & 1:10000	The first one with only the layout and the second one with the completely layout including laterals.	*	Inspect.	1
Preparing layout of drainage network	Layout shows alignment of major drains indicate with consistent numbering system.	*	Inspect.	0

*: Control Point E: Evaluation 1: Under control 0: Need more control

The suggested corrective actions for the design phase were also determined in relation to the control points and according to national and international experiences and approved with the experiences collected through the questionnaire as follows :

1. Distribution of design responsibility: The engineer who makes the field investigation must be responsible for the design work for the same project. It is also recommended to train the designers about the implementation phase.
2. Need for improving the design concepts and criteria: It is imperative to make field trials to evaluate currently used criteria and improve design criteria for areas that have special conditions. It is recommended to increase the minimum used diameter of collector to prevent blockage by sedimentation, use short collectors to improve the quality and also using of perforated plastic pipes for collector when water level is higher than the trench bottom. It is also recommended to use modified systems for rice growing areas.
3. Need for improving preparation of layout: Using of GIS in the design process to increase the efficiency of the design work.
4. Need for improving the lateral-collector connections: Using special connection for laterals to allow entry of jetting or any control equipment without excavate and dismantle the connection.

Tendering and construction phase was divided to main activities, components and elements. Specification and standards of each element were set. Control points of each activity were determined and evaluated. Specifications and control points of the activities are shown in tables (6 and 7).

Table 6: Specifications and Control Points of Tendering Process Activity

Activity	Description and Specifications	Control Points	Control method	E
Material				
– Tender document Submitted tenders	Project Information and specifications. Submitted tenders of contractors.	*	Inspect.	1
Planning				
– Contractors Pre-qualifying - Advertise tender	Contractors must be pre-qualified. EPADP advertise documents.	*	Inspect.	1
Processing				
– Tenders submit and judge	Tenders are judged on responsiveness of contractors to specifications and price	*	Inspect.	1

Table 7: Specification and Control Points of Construction Work Activity

Activity	Description and Specifications	Control Points	Control method	E
Material				
– Manpower	Engineers and Technicians.	*	Inspect.	1
– Material	Pipes, envelop material and water.	*	Inspect.	1
– Structures	Connections, manholes, outlets.	*	Inspect.	1
Machines	Leveling machine, the laying machines.	*	Inspect.	1
Planning				
– Collect pre-experience	Pre-experience of previous projects.	*	Inspect.	0
– Schedule project time and responsibilities	Implementation time is scheduled and assure of availability of manpower.	*	Inspect.	0
– Preparing work-shop	To produce concrete pipes and store materials and machines.	*	Inspect.	0
- Check plastic pipes and envelope material	Check quality and storage condition at workshop and field.	*	Inspect.	0
Processing				
– Deliver material to site	Check quality and quantity of materials.	*	Inspect.	0
– Construct outlets	Check the level and slope of outlet.	*	Inspect.	0
– Stake out collectors, laterals, and manholes	Determine level and slope of collectors and laterals and position of manholes.	*	Inspect.	0
– Installing manholes and crossings	Install required manholes, also T-connections, and required crossings.	*	Inspect.	0
– Lay collectors and laterals	Lay collectors and laterals with trencher or trenchless.	*	Inspect.	0
– Work evaluation	Evaluate quality of the work with new technologies.	*	Inspect.	0
- Delivery washing	Do a final check by flushing.	*	Inspect.	1

*: Control Point E: Evaluation 1: Under control 0: Need more control

The suggested corrective actions for tendering and construction phase are as following:

1. Judging tenders: It is recommended to pre-qualify the public and private contractors periodically to measure their eligibility for bidding and increase competitiveness.
2. Lack of feedback information: The feedback information from previous projects must be registered and collected to help in work planing.
3. Lack of time schedule and manpower organization: The time of implementation must be scheduled according to cropping and water management conditions to avoid any problems or delay. Work team must be assigned full-time to project site.
4. Low quality of plastic pipes: Plastic Pipes must be routinely tested, stored regularly, protected from direct sunlight and transported and handled carefully to avoid damages. Drainage machine should be equipped with a power feeder to prevent stretch.
5. Bad construction of outlets: Pitching with stones and mortar must protect the outlets. It must have a free fall into the open drain.
6. Low accuracy of the laser work: drainage machine should never install drains further than 300m from laser command post. Do not drive the machinery close to the command post as the vibration may affect the laser beam. It is also recommended to check periodically with levelling instrument behind laser to check the accuracy.
7. Poor quality of pipes laying: The lateral must be laid at proper elevation by using a backhoe to excavate holes at lateral/main line connections. Use trenchless machine especially with collapsing soils to improve quality of construction.
8. Low accuracy of evaluation work: Examine new techniques for inspection and evaluation at wide scale to determine their suitability under Egyptian conditions.

CONCLUSIONS

The main conclusions can be identified as following:

1. Low quality of the implemented subsurface drainage systems is attributed mainly to lack of adequate aspects of quality control.
2. The inadequate reliability of collected data in the field investigation is due to: the insufficient number of bore holes for field measurements, using of old date maps, make no levelling for the project area, and delay of the laboratory results. This also led to insufficient quality assurance for the construction phase.
3. Insufficient quality of subsurface drainage projects construction is related to: lack of planning before construction work and need for good distribution of responsibilities, bad conditions of transporting, storage and handling of material and need to improve inspection techniques.

REFERENCES

Abdel-Dayem, M.S. and Ritzema, H.P., 1990. Verification of drainage design criteria in the Nile Delta, Egypt. Irrigation and drainage 4: 117-131.

Abu-Zeid, Mahmoud, 1990. Physical features and drainage priorities in Egypt. Symposium on land drainage for salinity control in arid and semi-arid regions, volume 1, Cairo, Egypt.

Advisory Panel on Land Drainage and Drainage Related Water Management, 1996. Proceedings performance assessment workshop, 1996.

Ashford, J.L., 1989. The management of quality in construction.

DRI, 1993. Renewal of drainage systems in Egypt: Research and operational initiatives. A strategy paper prepared by DRI.

Johnston, William R., 1976. Drainage installation problems in the San Joaquin Valley, California, USA. Proc. of the international drainage workshop. Paper 4.01, publication 25.