QUALITY INDICATOR FOR DRAINAGE PROJECT IN EGYPT

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ABSTRACT

Drainage planning involves the preparation of a plan for the solution of the drainage problem. In most cases, however, the core of a drainage plan consists of the construction of some new drainage works. The detailing of such works, being mostly in the domain of engineering, is commonly referred to a three phases including design, installation, and operation and maintenance. The drainage system will operate satisfactorily in the long run if proper attention is given to quality control of these three phases. In this paper, an indicator is used to assess the quality of each phase. It deals with the practical results which are deemed useful for future end-users including planners, designers and construction supervisors of the Egyptian Public Authority for Drainage Project (EPADP), amongst others. An extensive study was carried to collect more than 130 questionnaires from the persons who involved in the different installation phase such as investigation, design, pipe factories and implementation. Moreover, 141 km of lateral drains were constructed in the North Behaira Directorate in the Western Part of the Nile Delta. During the installation an extensive data were collected about the performance of the construction techniques as well as the problem of installation.

Keywords: Quality Indicator, Quality control, Drainage, Construction

1. INTRODUCTION AND GENERAL BACKGROUND

The control of groundwater in agricultural lands is of great importance to prevent water logging and salts accumulation. This is usually performed by providing the land with an effective system of drainage. Once a drainage system has been installed, one must ensure that it well function properly for a long time. Technically, this requires that a good drainage base is maintained, that the system is inspected regularly, and that repairs and cleaning are done when necessary. Administratively, responsibilities for operation and maintenance must be well-defined, and an adequate budget must be available. In Egypt, it is common that, upon completion of the drainage work, the responsibility for the system is transferred from a construction department to an operation/maintenance department.

In a drainage design, drain depth and slope are specified. It is understood, thereby, that the grade line must be a straight line. In practice, this straight line can only be approximated. Because of many disturbing influences, deviations from the straight line are unavoidable. The commonly held view that laser-controlled machines cannot deviate from grade is a misunderstanding. Laser systems are very useful, but are no absolute guarantee of proper depth control, Ritzema [1]. For good drain performance, deviations must be kept within limits and error must be accepted to a certain degree. Norms for tolerances will now be proposed.

In the literature, a great deal of attention is focused on the magnitude of the slope, but little is given to the precision to which the prescribed line must be approximated. In flat areas, this precision is very important for drain performance. In pipe sections with a reverse grade, sedimentation of washed-in soil particles will concentrate, causing extra resistance to longitudinal flow. In relatively high sections, there is a risk of air collecting. Such air enclosures, also called air locks, may likewise impede the longitudinal flow of water. Van Zeijts and Zijlstra [2] mentioned that, in air lock formation, air can enter the drain pipe in different ways. This air generally cannot escape from the pipe into the soil, and has to be discharged through the drain outlet. When air locks exist in various places in a drain, their effect accumulates in upstream reach. The phenomenon of air locks has so far not been studied systematically, yet there are sufficient indications from practice that give reason and should be taken into account.

It must be no breaks or blockages in the drain pipe. Such disturbances are not always visible during installation. The visible inspections can, for instance, be hindered by the use of pre-wrapped envelopes and by collapsed trenches, and is completely impossible with the trench-less techniques. It is therefore important to check drainage systems for such disturbances soon after their installation. In the Netherlands, a control method has been developed to trace disturbances in the drains, van Zeijts and Zijlstra [3]. A steel bar, 0.9 m long, fitted with a torpedo-shaped head attached to a rod, is pushed through the drain pipe from the outlet to the other end of the drain.

In checking for grade deviation and obstructions in the drain, all drains should, in principle, be subjected to quality control. If, however, the costs of such activities are relatively high and relatively few errors are expected, one can work with random checks, van Zeijts and Zijlstra [3]. For this, the work is divided into sections beforehand, and a random check is made in each section. The contractor does not know in advance which drains will be included in the random sample. When the drains in the sample are found to be in order, it is taken for granted that all drains in that section are satisfactory. If one or more drains in the sample do not comply with the requirements, the sample is increased according to the certain predetermined rules. The contractor performs the control operations under the supervision of a representative of the principal. He does not receive any remuneration for any additional random sampling. Moreover, at his own expense, he must repair all defects found. With this procedure, it is to the contractors own advantage to do a good job, and he will therefore take all necessary measures to ensure that this is the case. Such preventive action leads to high quality at low cost, with few drains being checked, van Zeijts [4].

2. OBJECTIVES

The objective of this research work is preparing a Norm on quality or quality indicator for each phase of the drainage project such as: field investigation, design criteria, materials, maintenance and implementation. This will help the end-users including planners, designers and construction supervisors of EPADP to assess the drainage systems well.

3. COLLECTED DATA AND METHODS OF APPLICATION

This research work was built in collecting the experiences from Engineers who are responsible for the design, implementation and maintenance of the drainage system. The interviewed population includes people members differ in their experience years and social level and also from different directorates at different drainage regions. The total number of questionnaires which carried out with the technical staff was 6 for field investigation and design department, 34 for pipes factory department, 74 for implementation engineer department and 19 for maintenance engineer department. All these data were analyzed statistically by using the Statistical Computer Program (SPSS). This was mentioned also in technical study of the drainage research institute, DRI [6]. The norms, procedures, and checking method of: field investigation, drainage design materials, and installation of subsurface drainage system (including lateral and collector drains, manholes, connections, outlet of collectors, and backfill) were collected and discussed as follows:

3.1. Field Investigations and Design criteria

Selection of the area that is need for drainage

Norms: Many complaints about drainage problems in an area. The area is included in a plan for drainage implementation. Results of a preliminary field study confirm the presence of drainage complaints.

Quality Control: Review that the area has the conditions for drainage implementation.

Method of Application: conducting complaints processing and conducting a field study based on a grid system to check water table depth and its salinity, soil salinity and crop condition.

Field investigation to collect the design basic information

Norms: Collecting the basic data required for an area which has been selected for drainage implementation.

Quality Control: Review that, the field investigation is done according to the correct steps to collect the required data

Method of Application: Locating the area on the map with scale 1:25000 and preparing the topographic map with scale 1:10000. Provide the grid system on the map where each grid point represents an area of 500*500 m^2. Conduct an Auger hole on the grid point to investigate: soil salinity, soil texture, water table depth, and hydraulic conductivity.

3.2. Design of Subsurface drainage

Design concept

Norms: High water table, high soil salinity and low crop productivity.

Quality Control: Review that, the concept meets the agriculture and crop productivity requirements.

Method of Application: Developing concept from the agriculture and crop productivity requirements.

Basic Information needed for design

Norms: Hydraulic conductivity values, soil texture, soil salinity, water table depth and water salinity.

Quality Control: Review by design engineer.

Design criteria for lateral

Norms: drainage rate, drainage depth, spacing, slope, diameter, length and filter.

Quality Control: Review that, the criteria meet the agricultural and engineering requirements by the design engineer and director of works.

Design criteria for collector

Norms: drainage rate, depth, slope, diameter and length.

Quality Control: Review that, the criteria meet the engineering requirements by the design engineer and director of works.

Design work

Norms: Realizing the proper layout and design using the developed criteria and the area conditions.

Quality Control: Review that the design a according to the procedure and norms by the director of works and approved by the general director of FIRD.

Field check

Norms: Find the differences between the design and the actual situation of the area in order to reform the design.

Quality Control: Review that design is according to the procedure manual and instructions.

3.3 Drainage material

Lateral drain (PVC)

Norms: The pipe should be free of visual faults like cracks or blowholes. The pipes must be coiled of about100m length. The pipes surface should be geometrically regular and homogenous in thickness. The perforation must be generally even spaced around the circumference of the pipe in shape of regular rows (it must provide sufficient opening area to carry drained water at the specified hydraulic gradient of the pipe drain).

Quality Control: Visual inspection, dimensions check and mechanical tests.

Collector drains (PVC)

Norms: The pipe should be free from visual faults such as cracks or blowholes. The pipe surface should be geometrically regular and homogenous in thickness. The corrugation and wall thickness should score maximum strength and rigidity and comply with the minimum ring stiffness and weight per meter.

Quality Control: Visual inspection, dimensions check for weight, diameter and wall thickness and mechanical tests.

3.4 Implementation of the drainage pipe

Installation of the drain pipe

Norms: The field drains are constructed from PVC-perforated pipes with/without envelope material. The pipe shall be laid with minimum slope of 15cm/100m in a trench of at least 20 cm width. The pipe lying should be done mechanically by the machine which provided with laser apparatus according to the specifications. The maximum alignment tolerance is 2.0 cm; at any point provided that negative slope is not created. The pipe must be laid according to the design and the specifications. The lateral should be provided with end connection cap at its end as described in the design. If the pipe passes underneath any open canal or ditch, the pipe itself, must be not perforated and covered but a concrete pipe.

Quality Control: The quality control for implementation pipes drain could be done by using the Rodding techniques. It is a simple and easy method to check whether a drain is (partially) blocked, misaligned, crushed, or twisted. A metal bar with an enlarged probe or a metal cylinder is attached to a fibre-glass rod and inserted in the drain, van Zeijts [4]. Often a signal transmitter is fitted on the probe to make detection from the surface possible to determine the location of the probe inside the drain. Serious dents and sedimentation in the drain will be detected when the rod can not move any further. That will also be the case when the drain is misaligned over a short distance. The rodding method makes, it is possible to detect most of the drains that are not installed correctly, DRI [5]. Only absolute or exact information about the misalignment can not be measured with this technique.

Another technique could be also used for checking the quality of drains pipe, it is the Video Inspection techniques. This technique depends on a very high technology for checking the quality of the drainage pipe without any excavation. It is suitable for the research or very sensitive work. It consists of a video camera connected with fiberglass rods which transport a life picture into a T.V. mentor, DRI [5].

Collector outlet and pitching

Norms: using 3.0 m reinforced concrete pipe, pitching around it, and good connections. The pipe with diameter of 40 cm should be out of pitching by 1-2m with slope and level according to design. If there are errors in the installation of the outlets it should be corrected by the contractor or reinstalled. If collector outlet is submerged a

small dike shall be made at the outlet, pump water, and install the outlet and pitching or maintenance department shall react.
Quality Control: visual inspection, correct slope with good pipes and good connection.

Trench backfilling
Norms: trenches shall be backfilled over filter cover with the excavated spoil up to the ground level. No backfilling shall be allowed in a ditch under water or with too wet soil. Clods of soil shall not be used in backfilling; the fill shall be packed, but not compacted to such extent to render it impervious. Backfilling shall be done in successive layers; the first layer shall almost cover the collector pipe with a depth of 15 cm, and then continue in layers.
Quality Control: visual control and testing of compaction with ranging rod.

4. RESULTS AND DISCUSSION

4.1 Questionnaire Results

The summary results of questionnaire by the Statistical Computer Program (SPSS) in which the interviewed population includes people members differ in their experience years and social level and also from different directorates at different drainage regions. All the investigators mentioned that, damage, floating pipes; envelope, connections and manholes are checked as well as laterals levels and slopes.

4.1.1. Questionnaire results at field investigation and design department

Interviews were carried out with the Technical Staff having different years of experience and levels at field investigation and design department. The total number of this representative sample is six. The questionnaires revealed that, the field investigation report should be prepared by the field engineer including soil salinity, water table salinity, groundwater salinity, hydraulic conductivity, and other necessary field information and deliver it to the director of the work and have it approved by the director general of FIRD, Darwish [6]. Verification of field information is made by reviewing the work and take frequencies. Field investigation should be made with quite high accuracy and accurate grid points. Basic data needed for design are hydraulic conductivity, soil texture, water table depth, and soil salinity. Design discharge differs from area to another. Maximum area to be designed is varied between 5000 to 6000 feddan.

The quality control could be taken as, the field data and the information are checked first by field staff, then it checked again by the director of work, if the field information or the field data are wrong the action taken is checking all measurement and repeat sampling and the design work is checked by the general manager of FIRD to be sure that design is made according to norms, DRI [7].

4.1.2 Questionnaire Results with Implementation Engineers

Interviews were carried out with the contractor engineers of different companies having different years of experience and levels at the five drainage regions. The total number of this representative sample is 15. Also, an interview is made with total sample of 59 engineers at different directorates. The results of questionnaire by the Statistical Computer Program (SPSS) revealed that the errors discovered by checking might not recorded (10%) or recorded with daily reports (50%) or recorded on a map with monthly report (10%) or recorded in weekly reports (30%) as shown in (Figure 1). These errors are reported by technical (60%) or by engineer (40%). The actions taken with the errors are: it correct by directorate engineer (10%), stop working till the errors corrected by contractors (70%) or reinstalls it again (20%) as shown in (Figure 2). According to checking the laser equipment (80%) of the interviewers checks it before starting installation, while 20% mentioned that there is no check happens. The daily calibration of laser equipment is made by a specialized company (30%) or by leveling instrument (70%).

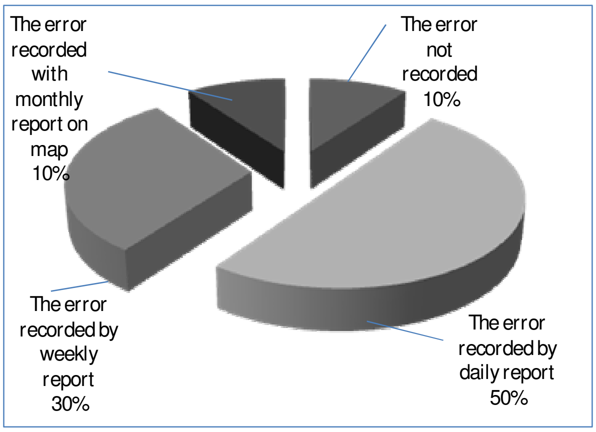

Figure 1. The way for record of the error found

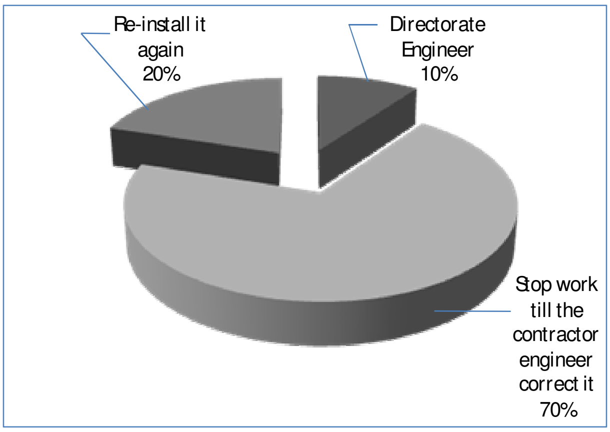

Figure 2. The action taken when the error is found

For field investigation and design engineer, all the investigators mentioned that, the standard methods and norms are well known and generally applied (100%) although the base material is the topographic maps which are often not of good quality.

According to the drainage materials; Norms, standards, testing procedures and testing facilities are mostly available. Norms for procedures and frequency of testing are either absent or not implemented. Most of quality tests mentioned in the contract document are not done especially for plastic collector pipes. Detailed descriptions of all necessary quality control tests (sampling, procedures, and equipment) on synthetic envelope are available but not applied.

To check lateral pipe levels and slopes laser equipment could be used (40%) or by leveling instrument (60%) as shown in (Figure 3). The question about the permissible errors in laterals slope indicated that 90% of interviewers gave the proper answer, while 10% gave wrong answer because they gave the design slope. Also, all interviewers said that, obstructions are checked before implementation. The method of checking damaged and floating pipes, envelope, connections, and manholes are carried out by visual inspection (50%) or by rodding equipment (40%) or no checking (10%) as shown in (Figure 4). According to lateral-connections and collars, the actions taken if some of it are not good stopping the work (30.8%) or by working with good one (69.2%).

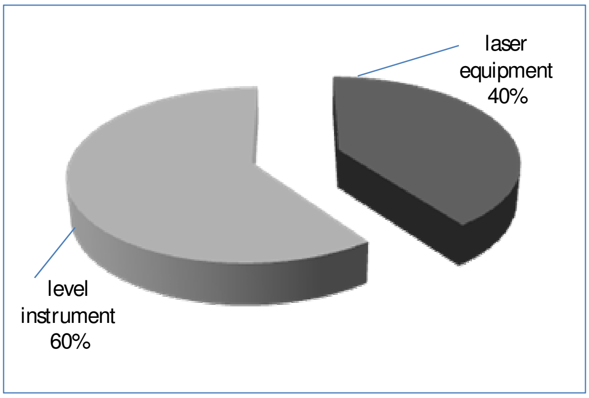

Figure 3. The method to check level and slope of lateral pipe

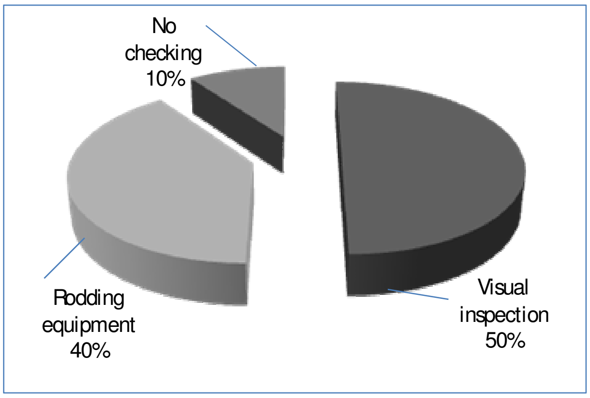

Figure 4 The methods for discover damage of Lateral pipe and connections

For the method of check collector pipes, all the interviewers mentioned that the final check of the level and slope is made visually, 70% mentioned that the errors are recorded, while 30% mentioned it is not recorded. The recording is made by technical staff of EPADP (14%), technical staff of contractor (72%) or daily report of the engineer (14%) as shown in (Figure 5). The actions taken with the errors, it correct by them (10%) or stop working till the contractor correct it (80%) or reinstall it again (10%) see (Figure 6). The actions taken if the outlets are submerged during installation due to high water level in the open drain are looking for reasons and solve the small problem quickly (8%) or maintenance of open drain (23%) or making a small dike at the outlet and pump water (8%) or using pump to decrease water level (15%) or waiting until water level in the open drain drops down (8%) or reinstall the outlet (15.4%) or contact maintenance department (23%) as shown in (Figure 7). All interviewers said that a final map with all modifications is prepared. This map is prepared by the staff of FIRD/EPADP (25%) or by the technical staff of the drainage directorate (75%). Also, all of them know the checking method of drainage system performance. The actions taken if the performance of the drainage system is low could be by correcting errors (100%). Also all of interviewers said that farmers are not participated during checking the layout of subsurface drainage system.

The method of check collector-outlets, the norms and specifications are known and clear for about 80% of the interviewers, while (20%) mentioned that it is not clear for them. All interviewers said that the criteria and specifications of reinforced concrete pipes are based on the Cigwart company table that is approved the Egyptian Public Authority for Drainage Project. There are two way for installation of the collector outlet, the first one is a three-meter reinforced concrete pipes and pitching around it with good connectors (61.5%) and the other is concrete pipe is out pitching by 1-2 m and using 40 cm pipe diameter with good slopes and levels (38.5%). The actions taken if outlets having errors are stop work and correct errors (38.5%) or by correcting errors (46.2%) or reinstall bad outlets (15.4%).

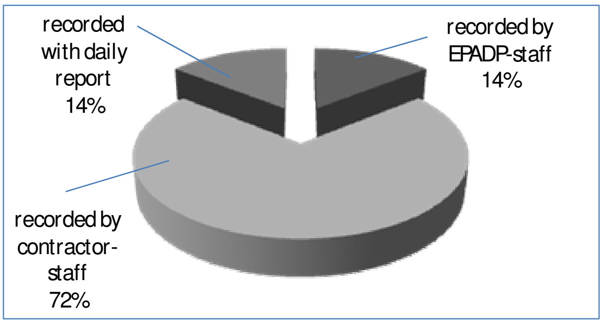

Figure 5. The way for record the error found in the collector pipe

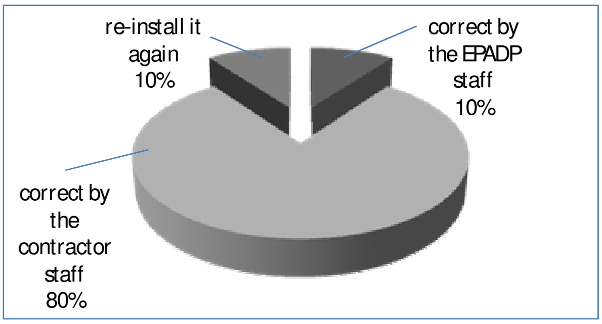

Figure 6. The action taken when found error in the collector pipe

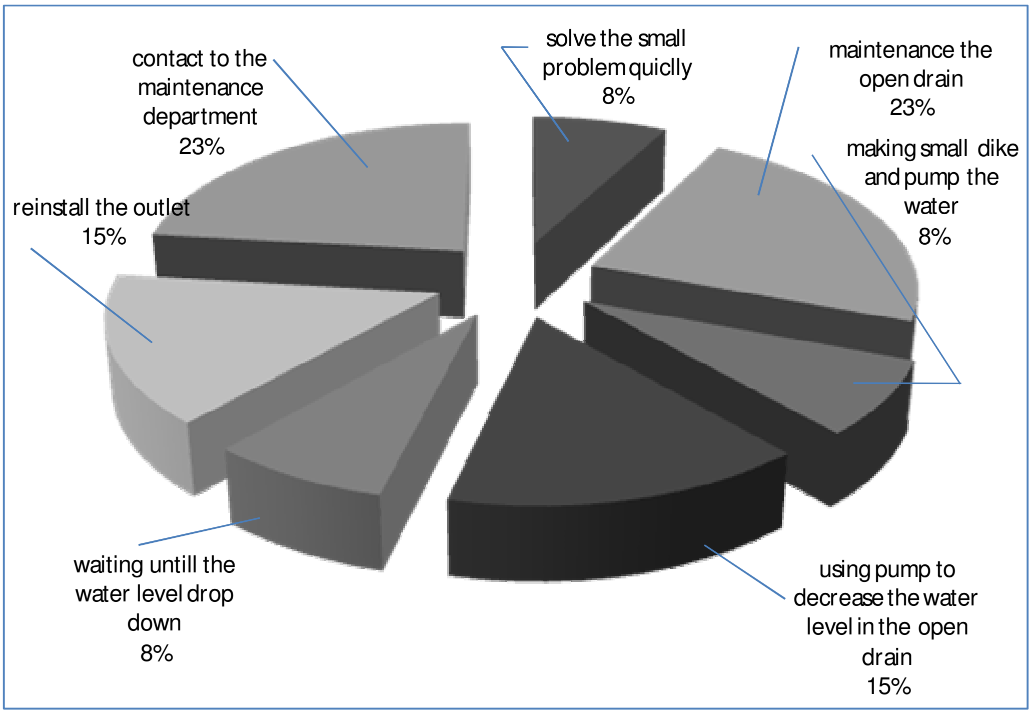

Figure 7. The action taken when the outlet of the collector is submerged due to high water level in the open main drain

All interviewers mentioned that a final map with all modifications has been prepared by the staff of FIRD/EPADP (10%) or by the technical staff of the drainage directorate (90%). Also, all of them know the checking method of drainage system performance. The actions taken if the performance of the drainage system is low, it could be corrects error (80%) or making flush the system (20%). Also, all of interviewers said that farmers are not participated during checking the layout of subsurface drainage system.

4.2 Constraints and threats of quality control process

Transport of the pipes to the workshop is done by trucks and from the workshop to the site by tractors with trailers. The trucks and tractor are not adapted for pipe transportation. The pipe coils are tightly strapped with ropes on the trucks or trailers with the results that many of the coils have one or more dents or cuts. Damaged pipe sections have to be cut-out during installation and the pipe has to be reconnected with a coupler. This procedure takes time, the machine has to stop, and wastes pipe material and couplers. When the pipes are wrapped with a synthetic envelope the situation is even more critical: dents and cuts are not visible anymore. Therefore, inspection of the quality of the pipe and envelope by the staff on the lateral laying machine and/or rodding of the lateral afterwards are very important, DRI [8]. Photo 1 shows the defects observed during the installation.

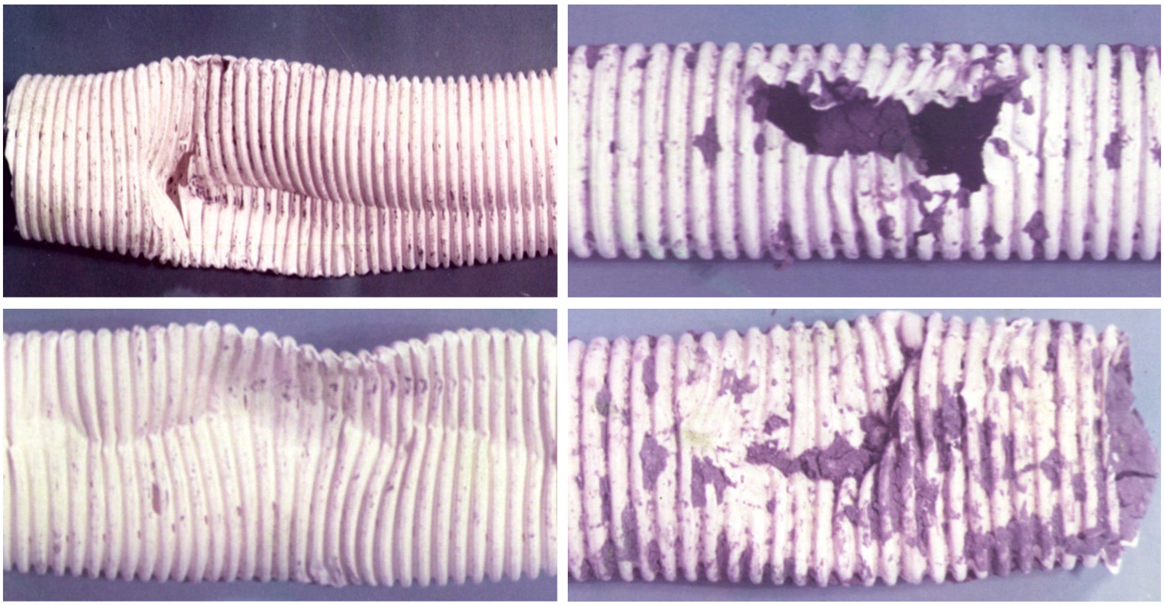

Photo 1. The defects of the drain pipe which were discovered by the rodding techniques

The collectors were made from polyethylene (PE), for the connection with the laterals the standard EPADP T-joint was used DRI [8]. The T-joints are usually installed before the laterals are installed. To prevent sediment inflow in the collector the T-joint openings are closed with jute cloth until the actual lateral connection can be made. A better closure could be achieved with a short lateral section closed at one side with an end-cap. These lateral sections could be temporarily inserted in both T-joint openings, be removed when the lateral has to be connected, and reused for the following laterals. If the double-sided T-joint is also used for single-sided lateral installation then these lateral section with and end-caps are also a good method to permanently close one side of the T-joint. Collector-lateral connections should be made at all time under dry conditions. The time period between the excavation of the pit and the installation of the laterals can be as short as half an hour but in the worst case, can also last for one or two days. During that time the water in the pit can rise as high as the groundwater level in the area. It is strongly recommended to install the laterals shortly after the pit has been dug or, when that is not possible, to bale or pump out the water just before the connection is made.

The lateral pipe inside the pit should be supported well by preferably undisturbed soil. A good excavator operator should be able to create a gradual sloping foundation for the lateral drain, from the lower end at the T-joint to the higher end at the side of the pit (Figure 8). Without this ‘ramp’, misalignment of the drain might occur when the pit is backfilled, or the drain can even be pulled out from the manhole or T-joint. If the excavator operator is not able to make a proper foundation for the drain it’s recommended that the pit is excavated not deeper than the design start level of the lateral drain, to be verified with a level instrument. The last part, up till the top of the collector, should be dug manually, with the above mentioned gradual slopes. Even when the lateral has a good foundation the backfill with the excavator should be done with great care.

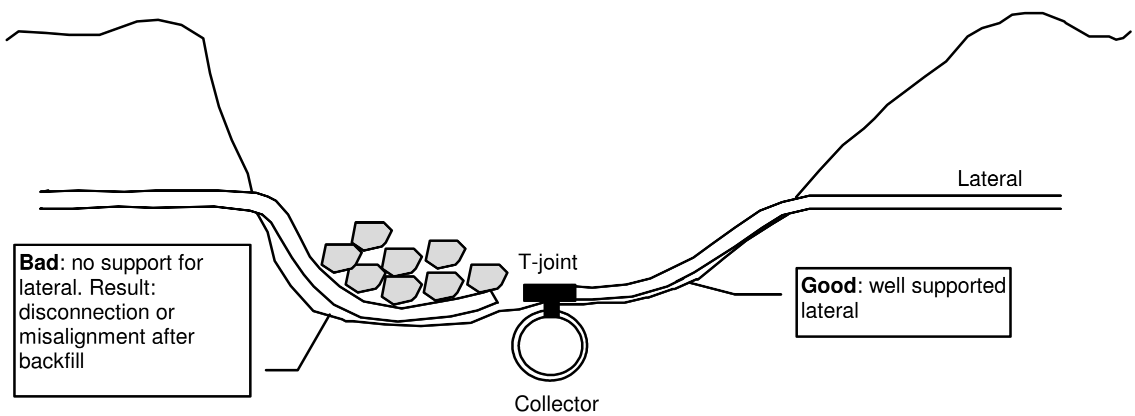

Figure 8. Backfill at the collector-lateral connection

During installation the envelope material at the lateral ends should be taped to prevent the loosening of the envelope, i.e. at the outlet of the lateral, at the couplers, and at the upstream end of the lateral. Handling of wrapped coils should be even more careful during transportation and in the field than coils without filter. Even if it is wrapped tightly the envelope damages more easily than the pipe, and dents in the coils are almost invisible.

5. CONCLUSIONS

The result of this paper indicated that the quality indicator remains critical issue for implementing cost effective and efficient systems. Egypt takes many active steps in that direction over the past years to achieve high quality products. It can be concluded from the results obtained that:

- Resent topographic maps for the field investigation and design engineer must be available in a good quality;
- Most of quality tests mentioned in the contract document are not done especially for plastic collector pipes;
- Standards and checking methods are absent for reinforced concrete pipes in the contract document. Also, norms of handling, transporting, and storage of different drainage materials (pipes and envelopes) are not applied in most cases. In other words the reporting system does not work properly;
- For implementation, there are no clear reporting procedures of quality control. Also, checking methods are well known but many installation materials are inspected visually which affect negatively on the quality of the work;
- The first line of defense in the struggle for better quality of drainage systems is undoubtedly prevention. Several steps must be taken to prevent misalignment and blockage of lateral drains such as: good training of machine operators and field supervisors on the setting and use of laser equipment and regular calibration of laser control equipment.

6. RECOMMENDATIONS

Based on the field investigation, drainage materials and implementation of laterals and collectors, it can be concluded that:

– A separate directorate should establish at the Egyptian Public Authority for Drainage Project to be responsible for quality control of the drainage projects.
– The contract must be contain the quality check aspects and the way when the defects are found. It must be mentioned the percentage of quality could be acceptable.
– Due to the aforementioned problems about application of norms, it was stated that some norms are not clear, while the others should be added as a new norms. Also, there are slightly big difference between some norms and the applied ones at different drainage projects

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