AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
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OPTIMIZATION OF THE OPERATIONAL PERFORMANCE OF IRRIGATION IMPROVEMENT STRUCTURES

CASE STUDY: DOWNSTREAM CONTROL GATES IN VEGETATED OPEN CHANNELS

by

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Abstract of Dissertation

Aquatic weeds growth is a one of the major problems which affect the flow characteristics in open irrigation watercourses, especially the small ones of 5-meters and less bed width which represent more than 80% of the irrigation network in Egypt, where the submerged weeds play an essential role in reducing the efficiency of water conveyance by developing a heading up in the water surface profile and increasing the response time of water supply required for irrigation, especially at the downstream reaches, as well as malfunctioning operation of control gates.

The principle of applying the on-demand water supply scheme is mainly to introduce downstream flow control gates to assure the availability of continuous flow throughout irrigation canals. Operation of these downstream control gates is absolutely a water level dependent, so that any change in the water level will affect the operational performance of the gate, and as a result, the amount of the flow ordered by the demand side will be no longer satisfied. The change in the gate's operation water level is mainly attributed to the existence of submerged flexible aquatic weeds with different reach lengths and densities at certain locations in the downstream zone of the canal.

The objective of this research study is to address the actual values of water levels, flowing discharges, operation status and main guidelines and proposed solution, which to some extent, optimize the operation of the gates subjected to weeds infestation in the downstream reaches and to give the prediction of the entire configuration of the weeds infestation. This of course will assist the water supply manager on taking the necessary measures for carrying out the canals weed control programs.

In order to achieve the goals of this study, five sets of experimental data points (400 runs) were carried out in the hydraulic laboratory of the hydraulic research institute (HRI). In addition, More than (200 runs) were conducted in SOBEK mathematical model to verify the experimental data points and simulate some other possible cases of weeds infestation. Each set included five runs at two different water depths (14 cm as maximum water depth and 11 cm as a minimum water depth) and different five gate openings for two cases of weeds infestation density. The flowing applied discharges were (7, 9, 11, 13 and 15 L/s).

The results of this study have revealed that the existence of submerged aquatic weeds with different densities at different locations in reaches of different lengths downstream the control gate in small canals, will result in the following: i- reduction in flowing discharges ranges from 17 to 66% in case of water level control, ii- a heading up of about (5 – 66%) of the design water depth at downstream the gate, iii- At any location of weeds infestation, the recorded heading up is directly proportional to the flowing discharges, i.e., the maximum the flowing discharges the maximum the recorded heading up (it ranges from 18 to 41 % for Y_0 equals 0.43b, and ranges from 35 to 66 % for Y_0 equals 0.33b, v- the value of Manning's roughness coefficient increases by (4 – 12) times its original value according to the weeds density and design water depth and flowing discharges, and iv- a decrease of (10 – 46%) in the design water depth at tail reaches was recorded.

Based on the results of this study, guidelines and adjusted operation rules of the downstream control gate were introduced to optimize the gate's operation so that it can respond to the actual situation and the status of the weeds at downstream reaches in small canals.

The entire data points of this research were used and elaborated in one programmable control concept through a software program (excel spread sheets based) deals with these data in two models. The first model builds on the data points recorded in the case B (flow control by a fixed water level downstream the control gate "Y_2" equals the design water depth "Y_0"), sensitized in the model as a signal came from sensor1 located at the measuring station downstream the gate, and the concurrent recorded tail water depth (Y_3) is less than (Y_0), sensitized also as a simultaneous signal came from sensor2 located at the tail of the canal. Here, the actual discharge due to weeds Q_w is less than the design discharge (Q_0). The second model builds on the results of the diagnostic model and the configuration of the weeds infestation, where it will deal with the processed values which correspond to the flow conditions in case A (flow control by keeping constant discharge (Q_w equals Q_0). The operation of this model is to allow the gate operation (open and close) until the signals of sensor1 (Y_2 is greater than Y_0 to the limit that is not exceeding the freeboard) and signal of sensor2 (Y_3 almost equals Y_0).

These mutually operated models gave the simplest way to get use of the data points of this present study in order to have a decision on the critical time of implementing the weed control program, especially during the periods of lack of financial resources of weed control program at a certain time. Also, it is the best tool to get use of and optimize the operational performance of the control structure without any malfunctioning due to false response to false signals of the system.

As a conclusion, the developed model also addresses the management of small irrigation watercourses from socio-economic and physical efficiency points of view, where it results in reducing the total losses encountered during the water conveyance in small branch canals and eradicating the water conflicts at downstream users.

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