Al-Azhar University Civil Engineering Research Magazine (CERM)
Vol. (44) No. (3) october . 2022

Lining of Al Qasasin new canal project, Egypt: an assessment and review

Dareen Gamal [1], Fahmy Salah [2], Tarek Hemdan Nasrallah [2]

[1] Engineer at Ministry of Water Resources, and Irrigations, Sharakia Governorate
[2] Civil Engineering dept., Benha Faculty of Engineering, Benha University, Benha Egypt

الملخص العربى :
تقتصر موارد المياه التقليدية في مصر على نهر النيل ، الذي يمثل حوالي 96٪ من موارد المياه التقليدية في مصر ، والتي تشمل أيضًا المياه الجوفية في الدلتا والصحاري الغربية وسيناء والأمطار والفيضانات المفاجئة. البطانة هي تطبيق مادة دائمة غير منفذة على سطح القنوات الطينية. كان الهدف الأساسي من تبطين القناة هو منع التسرب من قنوات الري الطينية وتحسين الكفاءة الهيدروليكية لعملية الري. يمكن استخدام البطانة في مجموعة متنوعة من المواقف اعتمادًا على الهدف الرئيسي للمشروع. يعد المشروع القومي لبطانة الترع من أهم المشروعات في مصر. الهدف الرئيسي لمشروع التبطين في مصر هو خط 6185 كم من القنوات. تقع قناة القصسين الجديدة على طول 43.800 كم على الجانب الأيمن لقناة السعدية بمحافظة الشرقية.تم استخدام دراسة حالة لتقييم مشروع تبطين القناة. اعتمدت نتائج هذه الدراسة على جمع البيانات من وزارة الموارد المائية والري في مصر .

Abstract

Egypt's conventional water resources are restricted to the Nile River, which accounts for around 96% of Egypt's conventional water resources, which also include groundwater in the Delta, Western deserts, and Sinai, rainfall, and flash floods. Lining is the application of a permanent impermeable substance on the surface of clay canals. The primary goal of canal lining was to prevent seepage from clay irrigation canals and to improve the hydraulic efficiency of the irrigation operation. Lining may be utilised in a variety of situations depending on the project's principal objective. The national project for canal lining is one of the most important projects in Egypt. The main target of the lining project in Egypt is to line 6185 km of canals. Al Qasasin new canal is located at 43,800 km on the right side for Al Saadia canal, Sharakia governorate was used a case study to assess the canal lining project. Results of this study depended on data collection from the Ministry of Water Resources and Irrigation in Egypt.

Keywords: Canal lining, seepage losses, MWRI, water resources, Sharakia governorate.

1. Introduction

ter is a vital component of the earth's ecosystems, redistributing it through natural cycles and contributing to climate control and the hydrologic cycle. Water is fundamental for feeding, food production, and economic production, FAO (1995). Water equality necessitates that everyone shares access to and entitlements to water, as well as profits from water use. Economic growth may be accomplished without addressing underlying disparities in access to water, services, and resources, but revolutionary economic development that benefits the poor and shares wealth can never be realised. Water shortage affects around 2.30 billion people worldwide. Water shortage is a barrier to development because per capita water use has fallen below the water poverty threshold.

Overpopulation is another big impediment to growth objectives. The population of Egypt in 2022 is about 110 million people and is predicted to grow by 2050, the limited amount of water resources pushes toward the preservation of these resources and reducing losses by all available means. Egypt is an arid country with an area of about 1001450 km^2, of which only 4% is occupied by its population. The population has tripled during the last 50 years, increasing from 19 million in 1947 to about 83.5 million in 2012 and 94 million (8 million outside and 86 million inside) in 2014, 99% of which is concentrated in the Nile Valley and Delta. The population is estimated to be about 100 million by the year 2025, Allam and Allam (2007). One of the key goals of the long-term strategy is to disperse the people across a greater region. To fulfil this goal, fresh lands must be reclaimed in order to provide food for the new communities. Egypt's per capita availability of fresh water has fallen from 1893 m3 per person in 1959 to 900-950 m3 in 2000, then to 670 m3 in 2017 and anticipated to be 536 m3 by 2025, according to Abd-El-Hai (2002). The major reasons for this fast decline are limited water supplies and increased population pressure. However, there are even more crucial aspects in Egypt's rising water concerns, as seen in Fig (1). There are many factors affecting the water stress in Egypt. The most important one is the social forces, depicts the social forces, dividing them into four levels-impacts of poverty, inequity, cropping patterns, and consumer behavior—that contribute to emerging water shortages. The Nile River, which starts beyond the country's borders and serves 11 nations, including Egypt, Sudan, and Ethiopia, contributes more than 96% of Egypt's freshwater resources. A 1959 international agreement between Sudan and Egypt reduced Egypt's access to Nile freshwater. The agreement granted Egypt 55.5 billion cubic metres (BCM) of Nile water per year, with Sudan receiving 18.5 BCM (1991). Egypt's current water consumption is projected to be at 89 BCM per year, of which the Nile River provides 55.5 BCM, making it the country's practically only supply of fresh water. The remaining water requirements are fulfilled by renewable groundwater (7.5 BCM/year) and drainage water reuse (8.5 BCM). Treated city and industrial wastewater return to the closed water system at 2.5 and 6.7 BCM, respectively; desert aquifers at 3.77 BCM; rainfall and lush harvesting at 1.5 BCM; and the remainder may be preserved by water management, according to Abdin and Gaafar (2009).

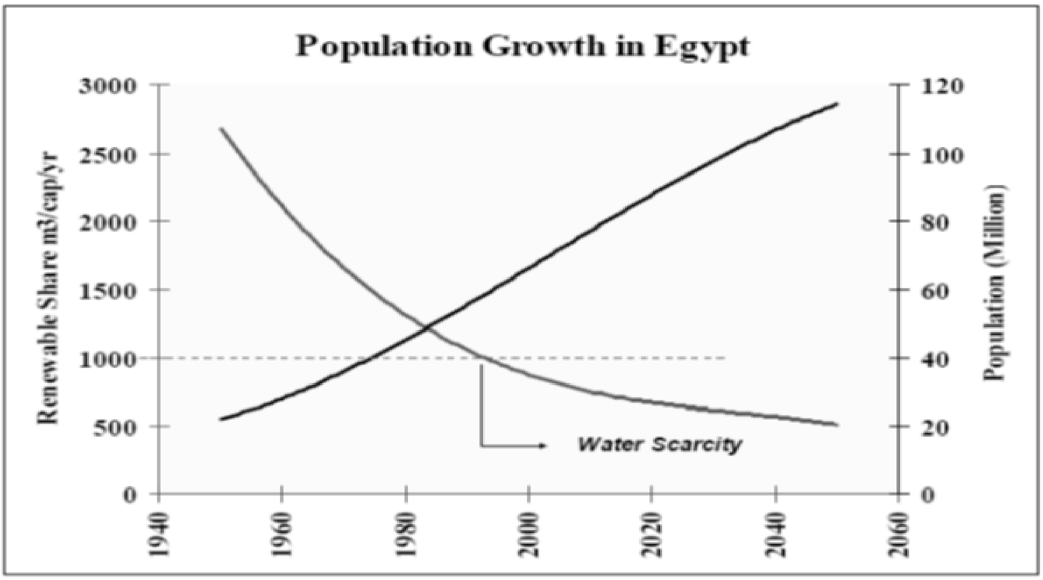

Fig. (1) Water scarcity in Egypt, Abd-El-Hai (2002).

There are several types of losses through the canal networks. These losses are played against development, especially in arid regions. The main types of losses include seepage, evaporation, transpiration, and operational losses. Although seepage is the greatest source of water loss, and can be minimized by canal lining, it is not usually executed because canal lining has a high construction cost.

Seepage loss is described as the gradual passage of water through the soil's pore structure through the wetted perimeter of a canal. Seepage loss ranged from 0.3 to 0.7 m3/s per 106 m2 of wetted perimeter, according to Swamee and Chahar (2015). The construction of an optimal liner might reduce seepage loss from canals. Hydraulic conductivity of the soil, canal geometry, head difference between canal water level and groundwater level, and aquifer border conditions all influence seepage loss. To calculate the seepage loss, many empirical formulae were modified. The Molesworth-Yennidumia Principle was one of the most important formulae utilised in Egypt (Swamee and Chahar 2015; ECP-2002 code for water resources and irrigation works).

$$S = C \times L \times P \times \sqrt{R} \quad (1)$$

Where: S is the conveyance losses (seepage and evaporation losses) (m^3/s), L is the length of the canal (km), P is the wetted perimeter (m), R is the hydraulic mean depth (m), C is the coefficients for soil type (stiff clay = 0.0015; very sandy = 0.0030). Egyptian code for water resources and irrigation works (2002) recommends the following equation for calculating seepage loss. Kraatz (1977):

$$S = 0.65C \sqrt{(Q/V)} \quad (2)$$

Where: S is the seepage loss m^3/s per longitudinal km length of the canal length, Q is the canal discharge m^3/s, V is the mean flow velocity through the canal m/s, C is the factor depending on soil type.

Evaporation is the process by which water changes from a liquid to a gaseous form by transferring heat energy. The following factors influence evaporation losses: Atmosphere temperature, Wind velocity over the water surface, Specific humidity in adjacent air. Transpiration is described as the process by which water received by a plant's root system is expelled into the atmosphere as a vapour from the plant's leaves and other surfaces. The growing vegetation in the canal produces increased resistance to the flow, lowering velocity, and increasing delayed time. The water loss caused by the canal system's operation is referred to as operational losses. Operational losses include the following: Overflow or breakage of canal banks, Loss at the end of the main canal or lateral systems, Leakage through gates and other control structures. Canal rehabilitation and lining could decrease the most water losses, but it requires higher budget and quality, Swamee and Chahar (2015).

2. Lining in open channel

Lining is described as covering the surface of earthen canals with a fixed impermeable material or any other material that can withstand erosion better than the material used to create the canal. The primary goal of canal lining was to prevent seepage from earthen irrigation canals and to improve the irrigation operation's hydraulic efficiency. Lining may be utilised in a variety of situations depending on the primary goal of the project, and the reasons of lining can be stated as follows: Seepage Control, Prevent Waterlogging of Agriculture Lands, Limiting Canal Losses, Expansion the Agriculture Land, Increase the Capacity of the Canal, Stabilization of Side Slope, Flood Protection, Limiting the Maintenance Costs, Maintain Water Quality, Increased hydraulic efficiency, Water is one of the most valuable natural resources, and conservation of water, supplies is becoming increasingly important as the demand continues to increase and new sources of supply became harder to find. Unlined canals necessitate significantly higher operation and maintenance costs for periodical elimination of silt, minor repairs, removal of water plants and weeds. The provision of lining decreases these costs significantly. Seepage from irrigated canals increase in ground water level if the canals remain unlined. This condition brings alkali salt to the surface rendering land unfit for cultivation. Kraatz (1977) mentioned that open channel that carry flow from (30 – 150 L/s) can lose about (10 – 15) % of its flow by seepage, and consumption of weeds.

Lining a canal will not totally eliminate these losses, but nearly 60 to 80% of the water wasted in unlined irrigation canals can be conserved by a hard-surface lining. (Abu Gulul, 1975) mentioned that seepage losses from earthen irrigation channels vary from (30-50) percent of the discharge available at the head of an irrigation system. Most nations employ concrete and geomembrane as principal canal lining materials, and China is no exception (Soomro et al., 2018). Lining saves water by reducing seepage, facilitating operation, increasing conveyance efficiency, and reducing weed growth. Together, this should increase the quantity of water available for irrigation, which in turn should result in a fairer distribution of water.

2.2 Lining Types

There are two types of open channel linings: flexible and stiff. Vegetative linings such as grass, rubble riprap, and geotextile or interlocking concrete grids are examples of flexible linings. Concrete, asphalt, and soil-cement linings are examples of rigid linings. The main distinction between rigid and flexible channel linings is how they react to variations in channel form (i.e., the width, depth and alignment). Concrete lining is widely used. Despite its high cost, it is long-lasting, impermeable, and hydraulically efficient, as seen in Fig. 2. This sort of lining is made of stone and mortar. However, the coefficient of roughness may be higher.

Fig. 2: Cast in place Concrete lining.

3. Canal System in Egypt

The Egyptian irrigation system is based on the Nile River, which feeds massive canals that divert just upstream of the Nile River's main barrages. Depending on the bed slopes of these canals and the position of the lower order canals, the flow has been regulated along the major canals by regulators or was divided into reaches. The canal system is quite intricate, particularly in the Delta. The flow from the main canal is sent to the branch canals, while the flow from the branch canals is delivered to the distributary canals, which supply water to Mesqas. The water level in much of the canal system is lower than the level in the fields, so farmers must pump water to their crops, according to MWRI (2020).

3.1 Lining of canals project in Egypt

The "lining of canals" project in Egypt is one of the most significant national projects now being undertaken, and it is one of the foundations of the state's ambitious strategy to optimise water consumption and meet the demands of all sectors in general, and the agricultural sector in particular. The canal lining project is now seeking to increase irrigation in an area of one million acres. Egypt has restored 6185 kilometers of canals. This project was scheduled to be completed between 2020/2021 and 2021/2022. The MWRI projected the project's principal budget to be at 18 billion Egyptian pounds (2020). The selection of the design technique to rehabilitate the canal cross-sections is dependent on many different parameters. These parameters include the type of soil, the canal discharge, the cross-section shape, the availability of constructed materials, and the cost. The widest spread of canal rehabilitation techniques is the rehabilitation using a layer of dry pitching under a layer of plain concrete. This technique is divided into three stages: earthen works, pitching layer, and plain concrete layer.

3.2 Problems face the implementation of lining in Egypt

- There are building encroachments on both sides of the canal
- The level of the upper foot is lower than the current bank level, which puts pedestrians at risk, especially children and vehicles
- Lining needs to develop maintenance equipment to suit its nature without causing damage to it

- The intersection of some channels with the railway, and this requires working with extreme caution due to the vibrations caused by the train and this requires taking into account these forces that affect the lining

After lining the canals, it is important to understand how to overcome the problems of lining by: Monitoring the pour joints and the locations of connecting water structures to the canal and finding out if there is water leakage from them or not, ensuring the integrity of the lining along the canal in the period of minimum needs, and providing the appropriate equipment for the maintenance of each type of lining separately

The Al Qasasin new canal is located at 43,800 km on the right side for Al Saadia canal. The length of watercourse is 7,035 km, while it services 3385 feddans. The length of the confinement to be rehabilitated is approximately 7,200 kilometers from the start to end. The location of the start of the canal with coordinates 31°58'708"N - 30°46'394"E. The design discharge of the Al Qasasin canal is 319680 m^3/s, and there is a secondary canal on Al Qasasin new canal, as shown in Fig. 3.

The selected canals suffer from many problems that affect their hydraulic efficiency, water distribution, which require evaluation. Among these problems are the presence of weeds on the it’s sides, the accumulation of solid waste in canals, the presence of some lining sections that need maintenance and expansion in cross section, as shown in Fig. 4. The aim of the study was to improve the irrigation status and the water reaching the ends of the canal, and to evaluate the canal and its branch before rehabilitation, to determine their hydraulic efficiency and the problems of the canals and to detect the most appropriate ways to qualify them and raise their efficiency and compare them with the evaluation of the same canals after rehabilitation, to achieve economic feasibility and sustainable goals for saving water.

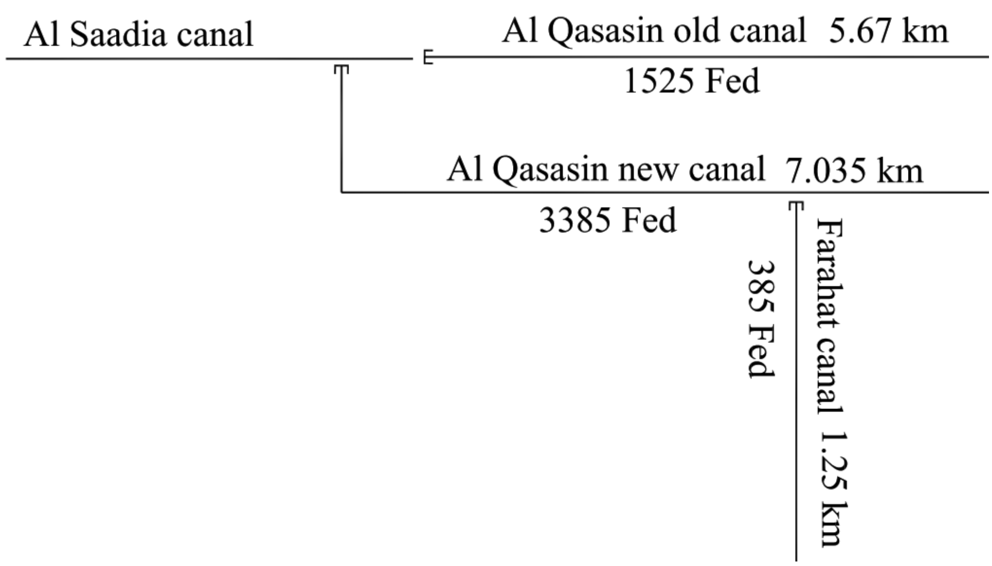

Fig.3 sketch of location of Al Qasasin new canal

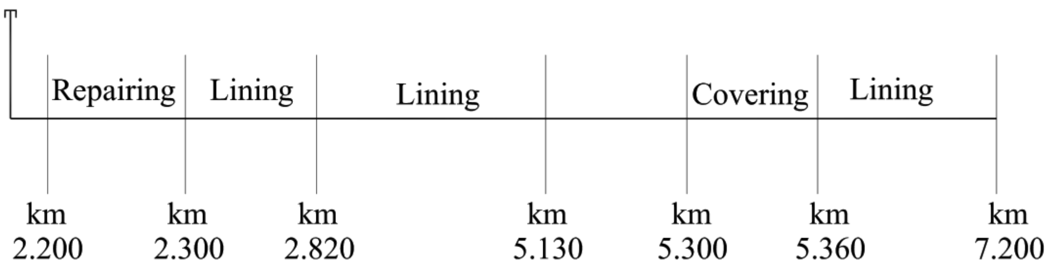

Fig.3 Expected rehabilitation work for Al Qasasin new canal

In this stage, field data and measurements will be analyzed, and this stage will include the following points before and after qualification:

- Plotting the various cross-sections of the waterway.
- Determine the discharges and calculate the speed in different cases.
- Design of qualified sections to raise the efficiency of the waterway hydraulically.
- The development of 1D numerical model representative of the canals before and after rehabilitation.
- Apply a number of different operating scenarios to the model.
- Evaluation of canals before and after rehabilitation, including infringements and violations on the canal before and after rehabilitation, a questionnaire of the beneficiaries before and after rehabilitation, access water to ends at the same discharge of the start before and after rehabilitation, water levels, and water velocity in the canal.
- Calculating the losses at the different sectors on each canal.
- Evaluation of the canal structural after rehabilitation.

3.3 Expected outcomes

- Evaluating the current situation of the canal under study and determining the dimensions of the problem.
- Provide a qualified cross-section with different sectors on each canal.
- Evaluating the canal under study after rehabilitating it.
- Conclusion of different relationships to approach a developed equation to evaluate the hydraulic efficiency of each canal
- Increasing the efficiency of hydraulic canals and the velocity of transferring water, reducing water seepage from the canal, and the equitable distribution of water.
- Decreasing maintenance costs
- Increasing agricultural productivity
- Improving the economic condition of farmers

There are many outcome aspects from lining project. These include economic, and environmental aspects. Most of the returns may interact with others. In many projects, one cannot easily separate between different returns. Satisfied judgement on any project depends on the comparison between inputs and outputs.

4. Conclusions

The primary goal of canal lining was to prevent seepage from earthen irrigation canals and to improve the irrigation operation's hydraulic efficiency. Lining may be employed in a variety of situations depending on the primary goal of the project. Unlined canals necessitate significantly higher operating and maintenance costs for periodic silt removal, minor repairs, and weed and water plant clearance. Several considerations, such as the position of the water table, climatic circumstances, availability of materials, speed of construction, time schedule, and performance of lining in existing canals in neighbouring regions, should be considered when choosing the kind of canal lining. Al Qasasin new canal is located at 43,800 km on the right side for Al Saadia canal, sharakia governate was used a case study to assess the canal lining project. Results of this study depended on data collection from the Ministry of Water Resources and Irrigation in Egypt. This study aims to assess the national canal lining project in Egypt. The study depended on collecting the data from the Egyptian Ministry of Water Resources and Irrigation.

References

1. Abd-El-Hai, M. (2002). Rural non-farm employment. Workshop “Current and emerging issues for economic analysis and policy research.” CUREMIS II NENA. FAO. INP.
2. Abdin, A. E., and Gaafar, I. (2009). “Rational water use in Egypt.” http://om.ciheam.org/article.php?ID PD F=801177
3. Abu Gulul, K. A. J. (1975). Lining of Irrigation Channels, M.Sc. Thesis, College of Engineering, Southampton University, India.
4. Abu-Zeid, M. (1991). “Water resources assessment for Egypt.” Ministry of Water Resources and Irrigation. Egypt.
5. Allam, M. N., and Allam, G. I. (June 2007). “Water Resources in Egypt: Future Challenges and Opportunities.” IWRA, Water International, 32(2).
6. Egyptian code for water resources and irrigation works (ECP-MWRI). (2002).
7. FAO. (1995). “Dimensions of need: An atlas of food and agriculture.” Rome, Italy.
8. Kraatz, D. B. (1977). Irrigation canal lining: Food and Agriculture Organization of the United Nations.
9. Ministry of Water Resources and Irrigation (MWRI). (2020). “National Project of Canal Rehabilitation.” https://www.mwri.gov.eg/tired-canals.
10. Soomro, A., Qureshi, A. L., Memon, N. A., uddin Abro, Z. (2018). Efficacy of Watercourse Lining in Sindh—A Review Study in Relation with Kohistan Region. Agricultural Sciences, 9(9), 1215-1227.
11. Swamee and Chahar. (2015). “Design of canal.” ISSN 2363-7633 ISSN 2363-7641 (electronic). Springer Transactions in Civil and Environmental Engineering, ISBN 978-81-322-2322-1, Doi 10.1007/978-81-322-2322-1.