Ain Shams University
Faculty of Engineering
Irrigation & Hydraulics Department

Optimal Design of Dams Located in Steep Slope Areas

(Khor Arbaat in Eastern Sudan)

A thesis submitted in partial fulfillment of the requirements of the PhD in Civil Engineering

By

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(B.Sc., Civil Engineering, Omdurman Islamic University, Sudan, 2000)

(M.Sc., in Civil Eng. Water Resources Engineering, University of Khartoum, Sudan, 2006)

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Cairo – 2016

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كلية الهندسة

قسم الرى

الموافقة على المنح

التصميم الأمثل للسدود الواقعة فى المناطق شديدة الأنحدار

(خور أربعات بشرق السودان)

إعداد

المهندس / أبوبكر طه بخيت طه

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Disclaimer

This thesis is submitted as partial fulfillment of PhD degree in Civil Engineering, Faculty of Engineering Ain Shams University.

The work included in this thesis was carried out by the author during the Period from.... to...., and no part of it has been submitted for a degree or qualification at any other scientific entity.

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

Student Name:

Signature:

Date: .... /.... / 2016

Dedication

To the pure soul of my mother and father in their eternity

The Sympathetic women ... which lead me to the first through science

The great man ... who did not die my imagination days

How I wish to be with me in these moments

,,,,,,,,,,,,,,,,,,,,

To the dearest and nearest ... my sisters whose devoted their life for my success

,,,,,,,,,,,,,,,,,,,,

To my wife ... Fatin

Without your love and support the completion of this work would have not been possible

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Abstract

Khor Arbaat is the main source of water supply for Port Sudan City, which is the capital of the Red Sea State, and second City in Sudan after Khartoum. Khor Arbaat originates from the Red Sea Hills and empties its water into the Red Sea Coast. Khor Arbaat is about 50 km to the city, and the Wadi has a length of 160 km with steep slope of 6 – 10 m per one kilometer which to high velocity of up to 4 m/sec. Therefore the Khor carries large quantities of sediments (up to 1553113.44 tons annually), which deposit in dams' reservoirs during the flood periods. Khor Arbaat receives high flood in summer (June, July, and August) and winter (November, December) seasons, but these quantities of water are useless.

There are three dams constructed on the Khor; Upper Gate Dam **1**, Sea Port Corporation Dam **2**, and Fourth Reservoir Dam **3** were designed for the water supply of Port Sudan town, they generally suffer from siltation and their storage capacity is decreased due to floodwater. The steep slopes of the watershed, the high rainfall, the soil type of the watersheds area, the less vegetation cover make the situation more conductive for greater erosion to take place in the Khor Arbaat catchment during rainy seasons.

This study aims to reach the optimum design of dams located on steeper slope areas such as Khor Arbaat in Eastern Sudan, and contribute to any mitigation measures that can be taken in order to reduce the amount of sediment inflow. This study proposed sediment settling basin to remove sediments by settling them into the basin.

The physical , topographical and hydrological characteristics of the watershed was related to the design of settling basin through developing the digital elevation model (**DEM**), watershed delineation, stream networks using **GIS** capabilities.

In this research, the total sediment loads were computed and the annual quantities of sediment which will be deposited in settling basin in future were predicted. In this study analysis was carried for thirty two sediment bed materials samples from different locations within upstream and downstream of Khor Arbaat dams. Sediment grading curves of bed materials samples were determined using sieve analysis, hydrometer test, and Atterberg limits. The grading curves described the sizes, distribution and pattern of deposition of sediment particles. The field investigation also included the siltation measurements inside Upper Gate Dam**1** and dry siltation inside SPC Dam **2**. GPS and GIS applications were used for determine samples location and other measurements.

In this research; Rainfall- Runoff process for Khor Arbaat watershed that lies in the northwest coast of the Red Sea was studied, the drainage watershed that contributes to seasonal floods was described, and the surface runoff volume, flow peak and flood hydrograph were predicted using **HEC-HMS3.5 Model**. Statistical rainfall analysis was done for yearly, monthly, daily rainfall data gauging stations surrounding the Arbaat watershed.