GEOTECHNICAL APPROACH TO CALCULATE SILT VOLUME IN DWERIGE WEIR RESERVOIR BY DIRECT SURVEYING METHODS

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ABSTRACT

Dwerige weir is a small hydraulic structure was constructed for reducing the flooding impact, irrigation regulation and environmental purposes. Also, the project was considered as a pilot water harvesting project in the eastern part of Missan Province. In this study, the problem of siltation in the weir reservoir was studied depending on the topographic surveying data of the reservoir, before it is was filled with water, and the final silt elevation taken directly during the reservoir drying period. The study uses the topographical and geotechnical approach to calculate the silt volume and the economic estimation of the economic loss of the project. A comparison between the designed and real project lives was made and the results are discussed in detail in order to avoid this problem in the future of the weirs and dams in the study area.

INTRODUCTION

The Ministry of Water Resources and Missan Government supported and founded the strategy to develop the water harvesting project in eastern desert. This project includes construction of three small weirs and dams to reduce the flooding risks and to use the flood water to ground water recharging. Dwerige weir is a pilot structure of this strategy (Ministry of Water Resources, 2009).

The reservoir siltation adversely effects on the weir or dam safety for different reasons. The reservoir sediment increases the load on the dam wall. The reduction of reservoir storage capacity reduces the attenuation of the flood and it may increase the outflow, hence

the head above crest, for a given reservoir inflow (Chanson and James, 1999). The amount of reservoir siltation is estimated by many methods, either by instruments or arithmetic models. Many approaches are developed to calculate quantity of annual or total siltation in reservoirs mathematically by computing river hydrology, geological properties of materials, suspended practical size, reservoir geometry and river basing drainage (Reinwarth *et al*., 2019; Mama and Okato, 2011; Rasol, 2018; Sánchez *et al*., 2018; Szatten *et al*., 2018; Tamene *et al*., 2006; and Wang, 2018). This study used new approach depending on the surveying data of the reservoir. Silt computation was achieved at the first year of weir operation. The Dwerige Weir Engineering Specifications is given as the following (Missan consultant engineering bureau, 2009):

-   Weir type/ Gravity small dam or (Weir).
-   Weir Length/ 512 m.
-   Total storage capacity/ 1,870,000m3.
-   Construction date/ 2016.
-   Cost/ 11.500.000 US $
-   Purpose/Dewerige weir is a multi-purpose structure. Used for flooding control, water storage for irrigation projects and groundwater storage.
-   Weir Base Elevation/ 29 m above sea level (ASL)
-   Weir Crest Elevation/ 32.5 ASL
-   Weir high/ 3.5 m
-   Weir Designed economic life: 50 Years

The objective of the study
       The first serious problem faced the Dewerige weir project in the first operation season is the amount of siltation in the weir reservoir. This problem reduces the workability and decreases the economic weir life (Fig. 1). The main objective is to study the siltation problem in Dwerige weir by computing silt quantity in the reservoir and then to compute the economic life reduction of the project. An easy and new practical method is developed in this study to calculate the amount of silts in the upstream reservoir area.

Location of the Dwerige weir

Dewerige weir is located to the South East of Missan province, Southern Iraq at UTM coordinates (741989E and 3551916N), adjacent to Iraqi – Iranian international border line, as shown in Figure (2).
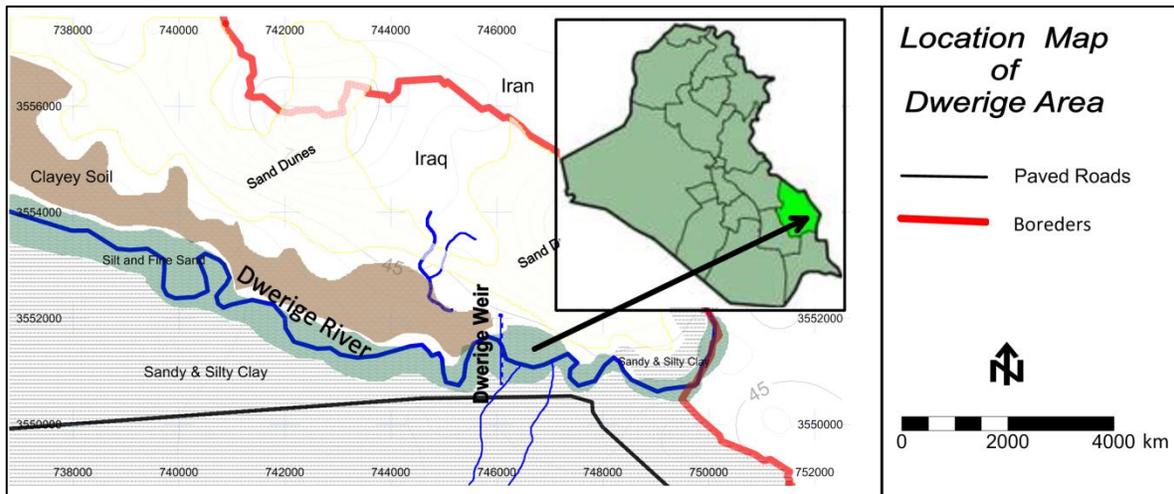
Geology of the area

The area is located within Zagros foothill zone, covered with wavy terrains. The Recent alluvial fan and aeolian deposits covering the area with outcrops of alluvial Quaternary and Tertiary deposits (Jassim and Goff, 2006). The geological map of the study area was drawn using satellite images and field works, Figure (3).

Dewerige river stems from Zagros maintain, in the Iranian territory, enters Iraq from southeastern parts at elevation of about 35 m and flow to the northwest direction then estuary in Hor Al-Sinaf, however about 90% of such river lies within Iran. It's a common border river between Iraq and Iran. The river is about 202 Km length, 800 m width, while the catchment area is given as 3270 Km^2. The average length of the river in Iraq is about 35 Km. Dewerige is a seasonal river and its discharge average is approximately empty in summer because it's completely dried. However, flooding occurs during the winter season (Ministry of Water Resources, Center of Studies and Engineering Designs, 2009).

Fig. 1: Siltation in Dwreige weir during first operating year

Fig. 2: Location map of the Dwerige weir
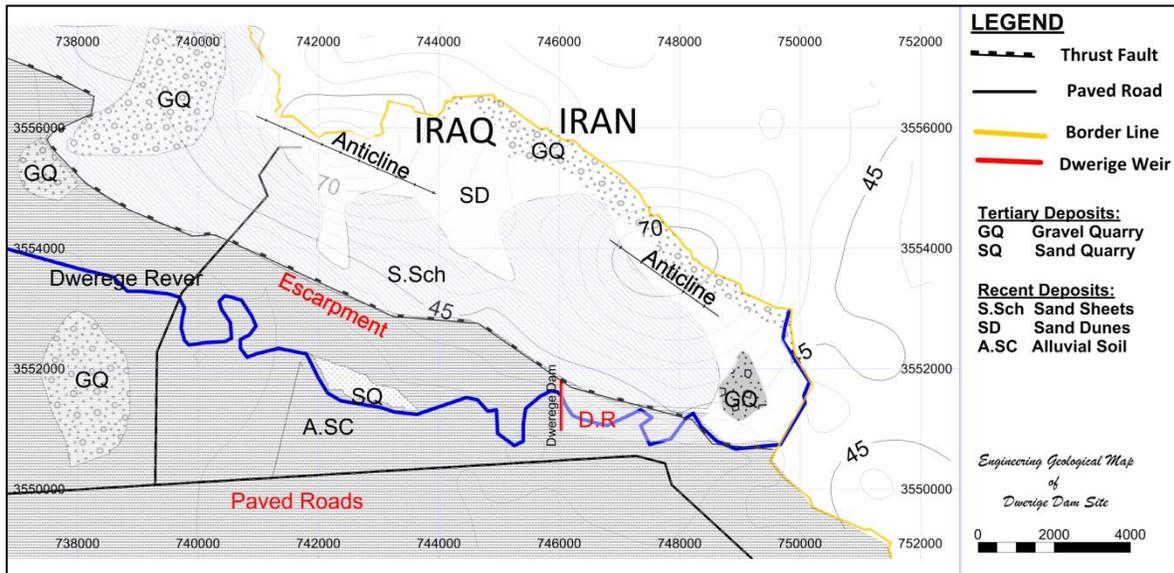
**Fig. 3: Geological map of the Dwerige area**

METHODOLOGY

To compute the silt thickness at any point in the reservoir the following approach is used as below:

a. Firstly, it is important to select a point of known original elevation as silt elevation bench mark (S.BM). In this study this point selected near the weir body.

b. The weir height (WH) = weir crust elevation (WRC)-weir base elevation (WRB) … (1)

c. Silt Thickness (ST) = WH-Distance from WRC to silt surface (SS) … (2)

d. Silt bench mark elevation S.BM = (point measured elevation+ ST) … (3)

e. in this study the point selected near to WRB and the equation is WRB+ST

f. The silt thickness at point i is computed ST(i) = S.BM-EL (i) … (4)

Where EL (i) is the measured original elevation of point i in the reservoir before water fill and siltation start to deposits, (Figure. 4).
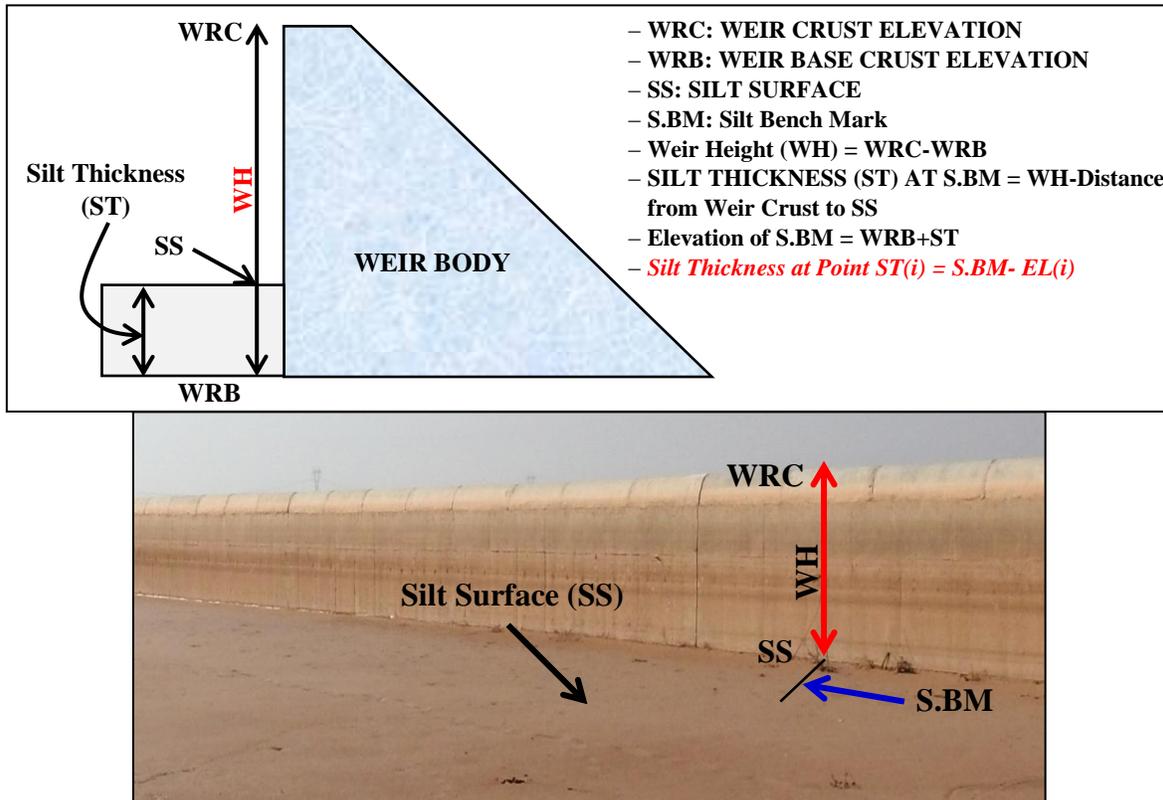
Fig. 4: The developed procedure for measuring the elevation of the silt benchmark

RESULTS

The Dwerige weir construction are finished at the end of 2016, however the study is started in 2017. The siltation benchmark is measured using equations 1 and 2 above in which the results were given as it follows:

WHB = 29 m (ASL).

WHC = 32.5 m

Distance from WHC to SS = 2.23 m

ST = 3.5 – 2.23 = 1.27 m the silt thickness above WRB.

S.BM = 1.27 + 29 = 30.27 m ASL (above sea level)

The elevations of the reservoir points are measured as shown in Figure (5). Each point elevation is subtracted from S.BM value. The results are represented in (x, y, z) matrix, where x represents the eastern and northern point coordinate respectively while z represent silt thickness at the measured point. Finally, the results are draw by software Surfer 16, and the total silt volume in the reservoir is computed by the software. The total volume of the silt to update in the Dwerige reservoir is found to be equal to 285337 m^3 (Fig. 6).
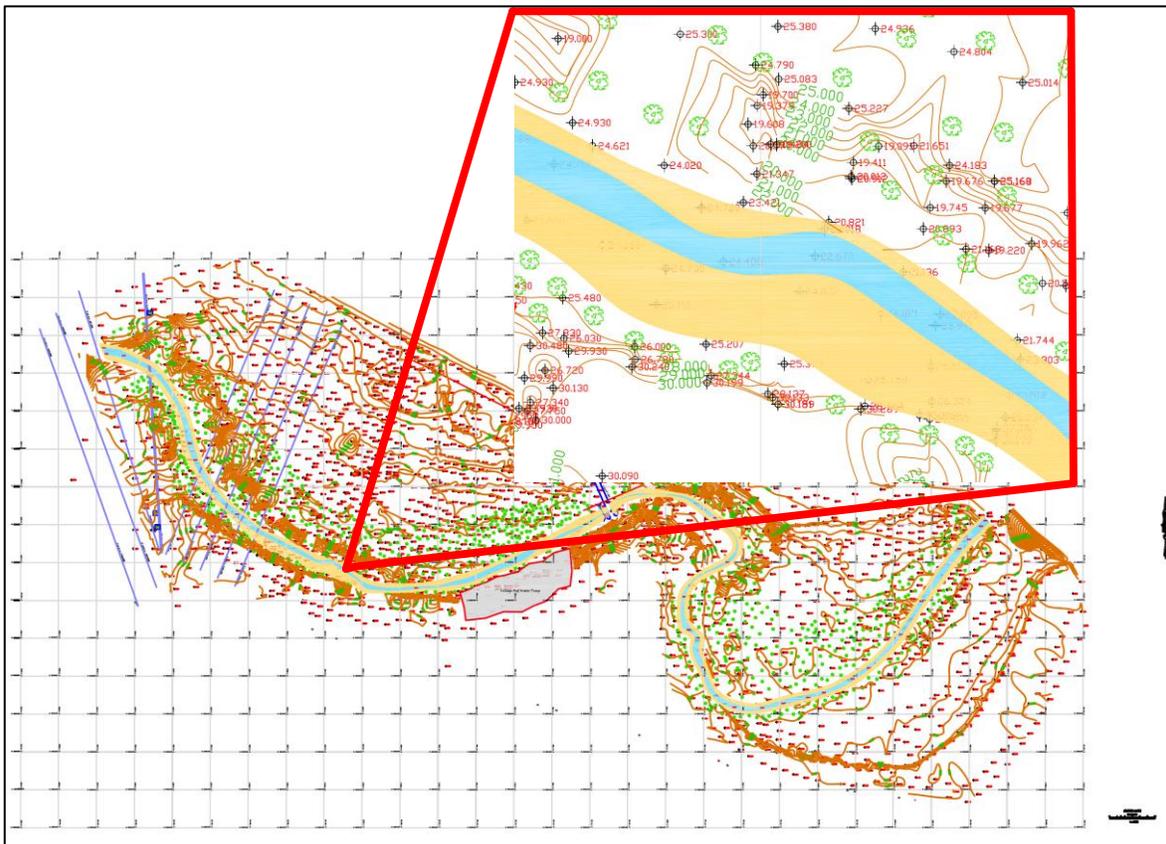
Fig. 5: The elevation points matrix of Dwerige weir
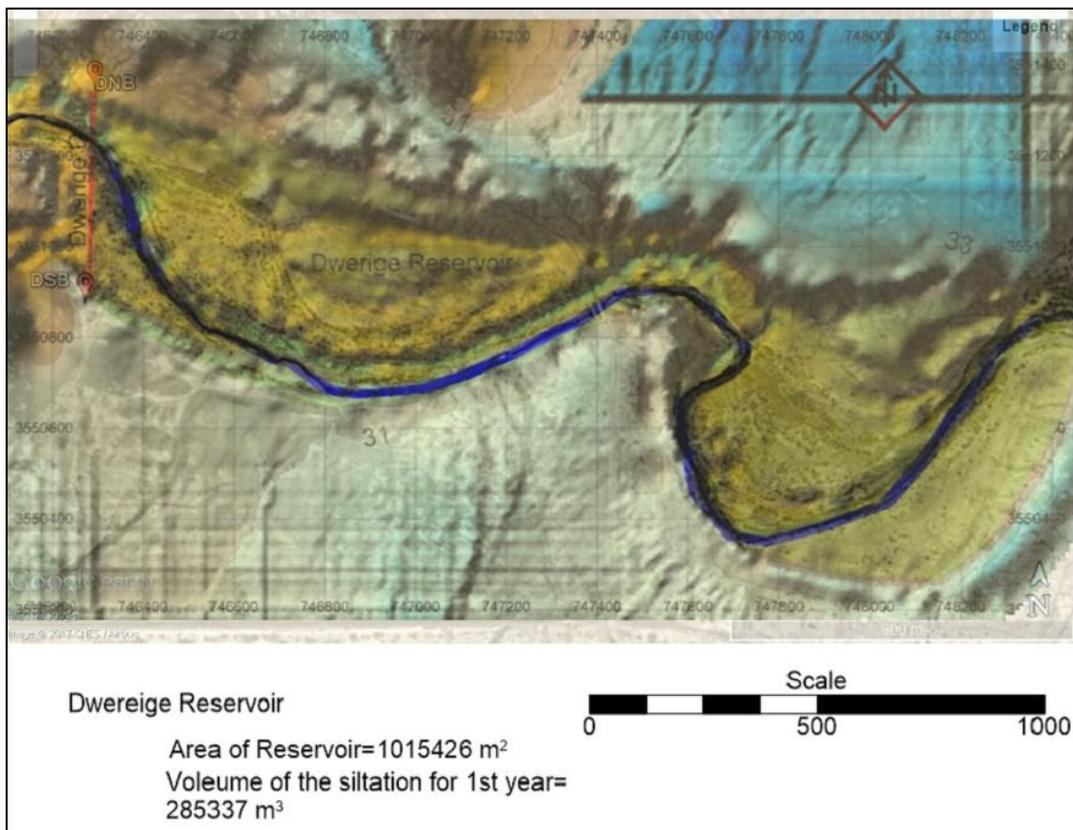
Fig. 6: The volume of silt in the reservoir

The reservoir storage capacity was divided on the calculated silt volume in order to find the weir true economic life. Then the true weir life subtracted from the designed weir life to compute the missing economic life.

True weir life = reservoir storage capacity/ Annual silt quantity … (5)

$$1870000/285337 = 6.5 \text{ years (about 6 years)}$$

Each year cost during project life is computed by equation (6)

Year Cost = Project total cost (US $)/ Designed economic life (Year) … (6)

By applying equation 6;

$$11500000/50 = 230000\$/\text{Year}$$

The lost period of economic reservoir life is about 44 year, this mean we have losing about ($10,120,000) of the total cost of the project (about 88% of the total project cost).

The above result show that the Dwerige weir will be filled with silt materials after six seasons, and its workability life will be finished if this problem will not be solved.

CONCLUSIONS

In this study, new practical approach is developed to calculate silt volume in weir and dam reservoirs. This method is applied in Dwerige weir, southern Iraq. Silt volume in Dwerige weir is measured during 2016/ 2017 season, which represent weir first operating year. The 2016/ 2017 season has low rainfall and may be described as dried season. However, the study shows that about 15.25% of the reservoir is filled with silt. The silt will reduce the storage capacity of the reservoir and increase the load on the weir concrete structure (Szatten *et al*., 2018).

The geotechnical studies are very important for selecting any dam sites, in order to decide which one is more suitable to construct the dam body even their type. Any neglecting in these roles causing economic and engineering losses.

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