THE STUDIES ON THE RATE OF SEDIMENTATION AT BEKOK DAM USING HYDROGRAPHIC TECHNIQUE

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Abstract

A detailed investigation is carried out into the method of hydrographic surveying to determine the rate of sedimentation on the riverbed. For this purpose, Bekok Dam is chosen as a suitable site for the research mainly due to the fact that the dam is suspected facing serious sedimentation problems from one of its tributaries. Three epochs of observations were taken over a period of one year. The technique involves using conventional position-fixing and sounding systems. Furthermore, the lead line technique of determining depth is also used mainly as a check on the depth obtained using normal echo sounder. The data set comprises of hydrographic surveys which were obtained by running the survey boat on a 5 metres sounding lines. Three separate hydrographic plans which were produced based on the three epochs of observations were plotted on a scale of 1:2000. It was found that the technique of hydrographic surveying could be used to compute the rate of sedimentation on the riverbed at an accuracy as required.

1.0 INTRODUCTION

Dredging job cost an immense amount of money. However one can reduce the cost by reducing the volume of dredging. This could be achieved if appropriate sedimentation studies is carried out. A range of techniques are available for assessing and predicting sedimentation rates. These techniques vary from assessments using limited field data to comprehensive numerical or physical modelling studies. Usually there are a minimum amount of data which is always

required before sedimentation studies can usefully be undertaken. These include (Dearnaley et al, 1994) :

Bathymetric survey data.
Tidal range and currents.
Bed material.
Suspended sediment concentrations.
Wind/wave conditions.

Additional data which will aid a sedimentation study are:

Historical bathymetric data.
Historical dredging records.
Present and past dredging strategies.
Through-depth measurement of tidal and suspended sediment concentrations at a number of locations.
Measurement of wave conditions at the site.
Measurements of sediment properties at the site.
Measurements of tidal and seasonal variations of suspended sediment concentrations.
Measurements of tidal elevation at the site.

For all these parameters, the most effective way forward is to use hydraulic modelling techniques. However, this paper describes the hydrographic technique for assessing and predicting sedimentation rate and the requirements for bathymetric survey data only, associated with the processing technique. The paper also indicates the importance of high density of sounding data to get an accurate assessments.

2.0 RESEARCH METHODOLOGY

The area chosen for this study is Bekok Dam in Johor. Although the main reason for choosing this area is because it is suspected facing serious sedimentation problems from one of its tributaries, other factors also influenced the selection. Among other things are that the area is not affected by the tidal factor and is well protected by the surrounding hills thus minimising the wind/wave action. Figure 1 shows the operational framework of the research. The main area of interest is the main channel of the dam (refer to Appendix 1, 2 and 3).

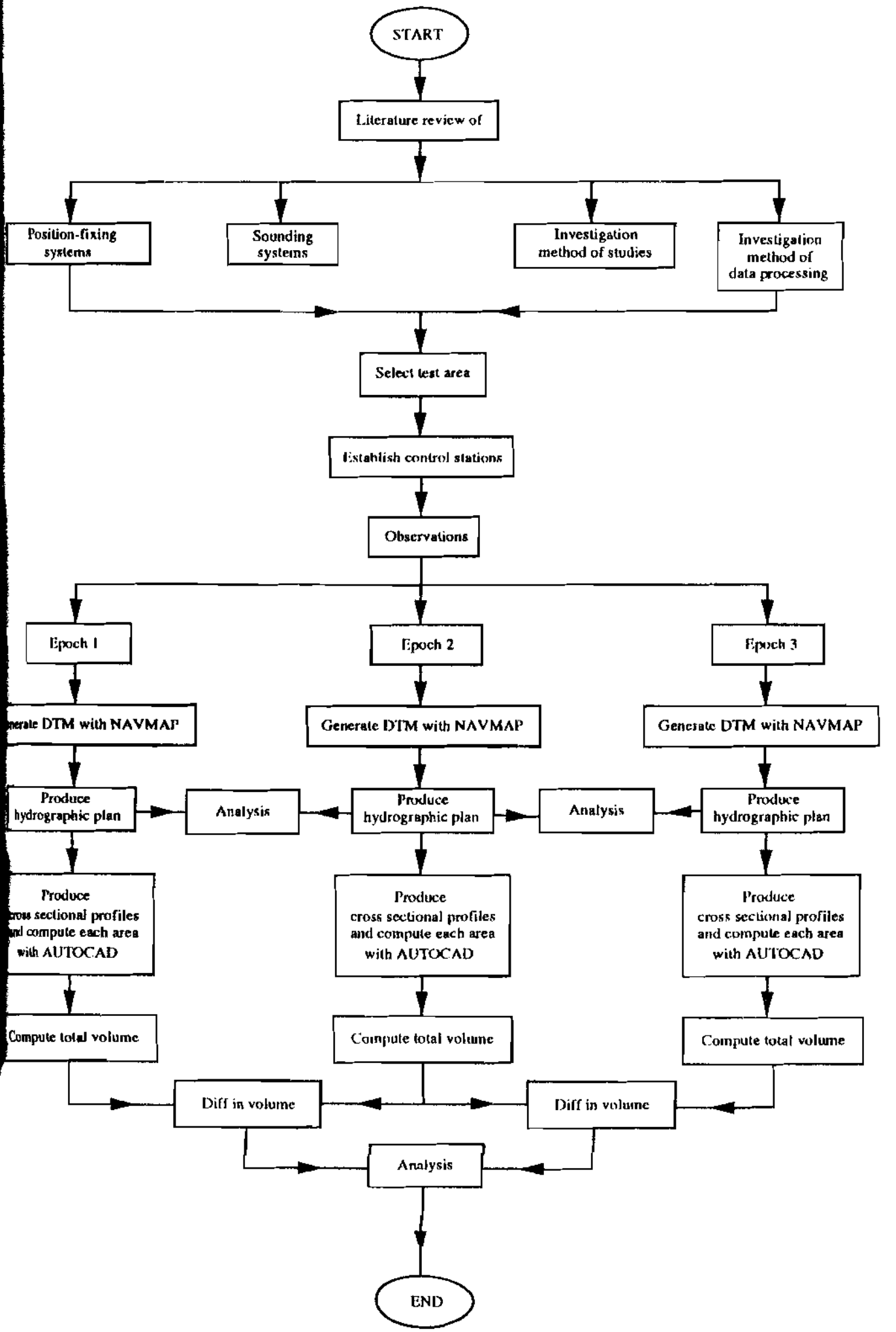
START
Literature review of
Position-fixing systems
Sounding systems
Investigation method of studies
Investigation method of data processing
Select test area
Establish control stations
Observations
Epoch 1
Epoch 2
Epoch 3
Generate DTM with NAVMAP
Generate DTM with NAVMAP
Generate DTM with NAVMAP
Produce hydrographic plan
Analysis
Produce hydrographic plan
Analysis
Produce hydrographic plan
Produce cross sectional profiles and compute each area with AUTOCAD
Produce cross sectional profiles and compute each area with AUTOCAD
Produce cross sectional profiles and compute each area with AUTOCAD
Compute total volume
Compute total volume
Compute total volume
Diff in volume
Diff in volume
Analysis
END

FIGURE 1

3.0 FIELD OBSERVATIONS

The survey were carried out using conventional equipment. These are Geodimeter System 500 Total Station for position-fixing and Raytheon DE-719CM echo sounder for soundings. Furthermore lead line technique of determining depth were also used as a check.

Three epochs of observations were carried out at an interval of six months. Although two epochs are already sufficient to determine the findings but the third epoch is necessary to provide the information for a whole year.

For hydrographic surveying one needs positioning system, echo sounder, survey boat and trained survey personel.

The soundings were carried out on a 5 metres line spacing at the main channel and 10 metres on other areas of the dam.

3.1 Control Stations

Four control stations were established permanently using nails and cements. It was necessary for all of the control stations to be on a high hill so as to make observations clearer and easier. The horizontal coordinates chosen were assumed coordinates. However the vertical coordinates are based on the existing Bench Mark established by the Department of Survey and Mapping.

3.2 Position-Fixing

The technique employed for position-fixing is based on the range-bearing method. The equipment must be set up on one of the control station. With the multiple prisms onboard the survey boat, the surveyor then tracks the prisms to get the position while simultaneously obtained the depth.

3.3 Soundings

Nowadays there are a wide range of single and dual frequency survey echo sounders available. All the systems are based on acoustic transceivers (transmittor/receiver) connected to an accurate electronic time measurement device. This timing device calculates very accurate the time between the departure of the transmitted acoustic pulse by the transducer and the arrival of the same reflected pulse by the bottom or target.

The depth (D) is then :

$$D = \frac{\text{Sound Velocity}}{2 \times \text{Time}}$$

3.4 Tide Readings

It was important that a tide staff be erected in the vicinity of the survey area and near the control station chosen as an observe station. These were necessary to record the depth of the water level during soundings and then reduced it to Mean Sea Level. In this way all the bathymetric data could be reduced to Mean Sea Level.

4.0 DATA PROCESSING

The depths obtained from the soundings were reduced to Mean Sea Level. It was found that these depths are between 11.5 metres to 13.5 metres. Appendix 1, 2 and 3 show the three hydrographic plans produced from the survey at a scale of 1:2000. These were plotted at a contour interval of 0.5 metres. Usually in hydrographic surveying, the depths are plotted based on the sounding lines. In this way the depths shown will be the survey depths and not the interpolated depths. However in this studies, different approach is taken mainly due to the fact that three epochs of observations will be carried out and for each epoch there would not be the same sounding lines. Furthermore, for each epoch of observations there would be seven cross sectional profiles produced and that all the profiles are related to the same horizontal coordinates. Thus for this reason the depths are obtained by NAVMAP (version 15.08) using a technique known as the Digital Terrain Modelling (DTM).

The DTM is a general technique which provides capabilities beyond normal contour plotting. Digital modelling is a method in which numerical data is used to define a three dimensional continuous surface. Here, the input to DTM is a set of irregularly spaced (X,Y,Z) samples of a smooth continuous or a faulted (discontinuous) surface. DTM processes the raw data and reforms them into a grid format so that they are in an adequate form for cross section or centre line profile plotting and modelling. It will be more accurate if the density of data is higher.

Appendix 4, 5 and 6 show seven cross sectional profiles (between N1040 metres to N1160 metres with an interval of 20 metres) of the main channel for each epoch of observations plotted using AUTOCAD release 12. These informations were used to compute the area of the cross sectional profiles from the datum level.

Thus, the volume computed are also based from the datum level (MSL). These were obtained using the Average End Method or Trapezoidal Method as shown below:

$$\text{Total Volume} = 20 \times 1/2\ [CS1 + 2(CS2 + CS3 + CS4 + CS5 + CS6) + CS7]$$

whereby 20 is the interval between the cross section

and CS1, CS2, CS3, CS4, CS5, CS6, CS7 are the cross sectional areas.

Cross Sectional Profile	AREA (m^2)		
	Epoch 1	Epoch 2	Epoch 3
1	10638	10769	11076
2	10657	10784	11066
3	10727	10788	10874
4	10600	10632	10716
5	10773	10813	10726
6	10831	10845	10722
7	10679	10809	10826
Total Volume	1284930 m^3	1293020 m^3	1301100 m^3

TABLE 1

5.0 RESULTS AND DISCUSSIONS

The analysis made is based on the following :

The hydrographic plans.
The cross sectional profiles.
Difference in volume.

i) The hydrographic plans

The three hydrographic plans show that there are movements on the riverbed. As expected, the main concentration of the movements is in the main channel. This is clearly shown by the bathymetric contour on the hydrographic plans. Nevertheless,

the movements are difficult to predict if they are based on the hydrographic plans alone.

ii) The cross sectional profiles

Comparing each cross sectional profiles from the difference epochs obtained, it was found that the increase in sedimentation was constant and could be predicted. An accurate prediction of the whole area could be made if more cross sectional profiles are produced.

iii) Difference in volume

The results show that there are an increase in volume for every epoch. The difference in volume between epoch 1 and 2 is 8090 m^3 whereas the difference in volume between epoch 2 and 3 is 8080 m^3. This shows that there is a constant rate of sedimentation occuring in the area with an average of 8085 m^3 for every six months or 16170 m^3 in a year.

6.0 CONCLUSIONS

The technique of hydrographic surveying could be used to compute the rate of sedimentation occuring on a riverbed. However further studies need to be carried out for areas of the river and sea that are affected by the tidal, wind/wave conditions, etc. The technique stress the necessity of carrying out at least 3 epochs of observations to determine the rate of sedimentation for a particular area. The accuracy of the technique depends on the density of the soundings obtained. An accurate assessment could be made if the density of the data is higher.

7.0 ACKNOWLEDGEMENTS

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