PROPOSED MODEL FOR DREDGE VOLUME CALCULATION AT SHARM OBHUR, THE RED SEA

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Abstract — The calculation of dredging volume is very important in estimating and implementing the dredging study. A comprehensive case study was conducted at the proposed Sharm Obhur site to calculate the amount of dredging necessary to facilitate berthing facility. Hydrographic surveys were conducted to identify topographical features at the proposed location. Hydrographic data was used in volume calculations through triangular irregular network (TIN) volume estimation techniques in the geographic information system (GIS). A study conducted at Sharm Obhur creek in the Red Sea using the GIS model and quantitative analysis was carried out. The study revealed that the GIS-based TIN volume model is more accurate, easier, and faster than other models available on the market. The study has significant practical potential for design, estimation, and development in the marine sector.

Keywords: Hydrographic survey, GIS, dredge volume, TIN model

1. INTRODUCTION

Safety navigation is one of the major concerns in coastal, near shore, harbor, and inland navigation.

Navigational

safety is dependent on various factors, amo ng which the depth of the navigation channel is important. Maintaining a desired depth for safe navigation is one of the major challenges in places where sediment transport occurs more often, such as near estuaries, accretion zones, etc. Desired depth in these areas can be achieved by dredging, a process which is quite costly [1]. Sediment quantification is important for estimating project costs in the dredging sector. Hydrographic surveys are needed to estimate the volume to be dredged and to conduct feasibility studies. Both pre- and post-dredging surveys provide a full picture of the dredged area. Multibeam surveys provide topographical details of an area and can be used to quantify the volume of material to be dredged. In hydrography, backscatter surveys help determine what type of material to dredge and calculate dredging costs. Detailed hydrographic survey data may be used in computer models to estimate the amount of dredged material.

Near-shore areas, harbors, rivers, inlets, etc., must be dredged in order to ensure safety and economic viability during navigation. To estimate how much material needs to be dredged, pre- and post-hydrographic surveys are required. There are several ways to calculate volume dredging to estimate a project's cost. The available methods each have their individual characteristics and vary with predictive accuracy [2]. The present investigation is a case study from a berthing

area near the Faculty of Maritime Studies (FMS) by the Sharm Obhur, a coastal creek off the coast of the Red Sea approximately 35 km north of Jeddah. The Sharm Obhur has a safe navigation channel and any large survey vessel with more than 4 m draft cannot berth in the FMS berthing area. The bottom topography near the berthing area is too shallow and complex with an average depth of 3 m. In the future, deepening the berthing area will allow large survey vessels to berth near the FMS. The faculty owns another large research vessel which is too large to berth in the FMS berthing facility. The current study was undertaken in order to deepen the berthing area and ensure the secure berthing of survey vessels with drafts more than 4 m. The present study can be also used to calculate dredge volume for the proposed berthing area.

2. MATERIALS AND METHODS

The primary and secondary data collected was processed, analyzed, and used for quantitative assessment of the dredging volume. The primary and secondary data collated from the hydrographic department as part of the study was processed using different software accordingly. The hydrographic survey is an essential tool for the planning and execution of various dredging phases, particularly for ports and harbor developments [3]. The hydrographic data consists of side-scan sonar, multibeam sonar, sound velocity profile sonar, and other types of data. These different survey techniques were adopted for data collection and processing. Dredge volume calculations require a pre-dredge survey and other related data for better results. Common techniques used are the grid model and triangular irregular network (TIN) model [4, 5]. The TIN model can be used efficiently with a high-density data set (multibeam) using a geographic information system (GIS) [6]. The hydrographic data utilized in dredge volume calculations used several volume estimation methods. The multibeam data processing, TIN model, volume calculations, tide correction, sound velocity correction, and generation of the base surface for the final enhancement were all improved using the HYPACK program [7]. The final surface was created with the HYPACK HYSWEEP editor after several data processing steps.

2.1. Study area

The study area of Sharm Obhur is roughly 10 km long and 500 m wide [8]. Since the 1980s, its coastlines have been steadily urbanized. The Sharm Obhur has a complicated topography with an average depth of 30 m [9]. It has a narrow outlet with a width of 264 m that connects to the main Red Sea at its southwestern end. Coralline limestone extends inland from the Sharm Obhur, where temperatures range from 24.4 °C in winter to 32.2 °C in summer and generally rise towards the creek's head [10]. Fig. 1 shows the study area. Due to the tidal cycle, the diurnal water exchange takes place at the bay's mouth. The proposed dredge area selected in the Sharm Obhur channel is shown in Fig. 2.

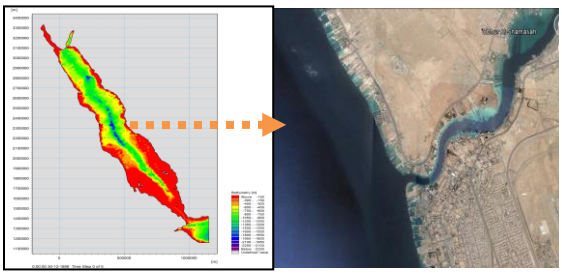

Fig. 1 Study area, Sharm Obhur, Jeddah

Fig. 2 Proposed dredging area

2.2 Data collection and analysis

Data was collected by multibeam survey in the study area. HYPACK software was used in this stage to enhance the multibeam data, apply tidal and sound velocity corrections, and generate the basis surface for the final enhancement. In the course of processing raw data, corrections for rotational motion (IMU), tide, and sound velocity were applied. Different techniques were used to generate a bathymetry map of the study area (Fig. 3).

2.2.1 Triangulated Irregular Network (TIN) model

Delaunay triangulation [4] is commonly used to create TINs. The TIN model can be effectively used with high-density data sets (multibeam and single beam) with the help of a geographic information system (GIS). TIN model a vector based representation of land or sea topography. The TIN model is based on the comparisons of two terrain models. In this technique, the surveyed surface represents the first terrain model and the planned dredging surface (design surface) represents the second terrain model. A TIN model was generated using Arc Map with XYZ data in the study area. The data was exported as Geo TIF to create a TIN model in the Arc Map. The TIN model was generated in high resolution (Fig. 4). The details of the TIN model area provided in Table 1.

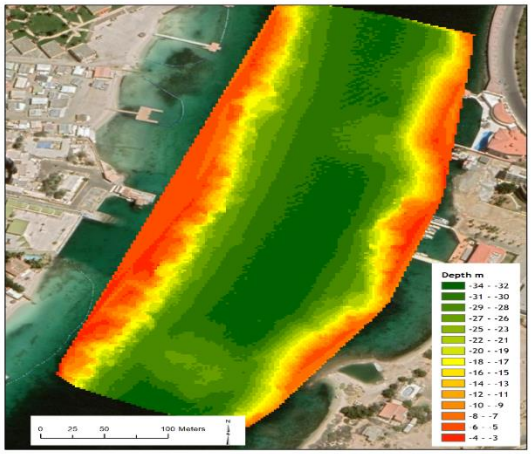

Fig. 3. Processed bathy surface at the study area

Fig.4. TIN model for the study area

Table 1. Details in TIN model

Items	Description
Triangulation Method	Delaunay conforming
Number of Data Nodes	801663
Number of Data Triangles	1603294
Z Range	-34.48 m to-2.39 m

2.2.2 Volume calculation

The volume was calculated for a minimum depth of 15 m and hence the reference depth was fixed at 15 m (by considering future needs). A depth contour of less than 15 m was selected near the berthing facility and is given below in Fig. 5. The total area in the berthing facility with a depth less than 15 m is 2405.74 m^2. The volume was calculated for this area to maintain a minimum depth of 15 m. The total computed volume to be dredged to maintain 15 m is 12794.66 m^3.

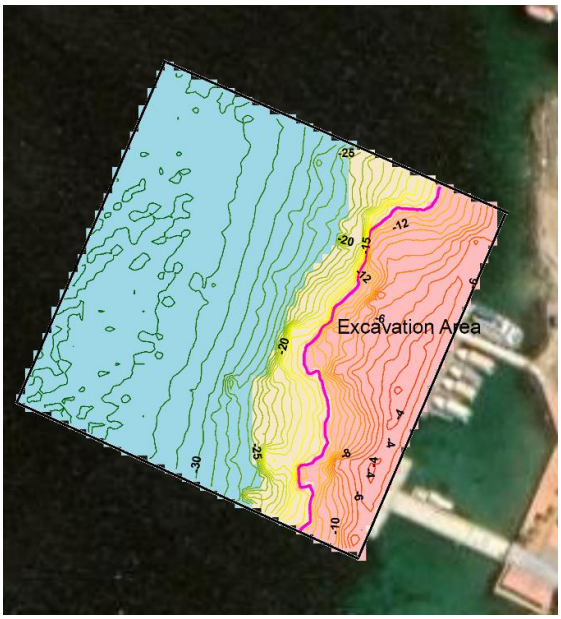

Fig. 5. Proposed Excavation area

3. CONCLUSION

The study focused on quantitative dredge volume calculations at the proposed berthing area near the Faculty of Maritime Studies (FMS) by the Sharm Obhur creek using GIS and TIN volume computations techniques. The objectives were specific and involved comprehensive data analyses and studies conducted with limited resources. The upper and lower surfaces (design surfaces) were designed and dredge volume was calculated using GIS techniques. The total computed volume to be dredged in the proposed area to maintain 15 m is 12794.66 m^3. The present investigation can be considered a feasibility study for related studies with similar objectives.

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