Estimating the Rate of Sediment due to Tidal Currents in the Port SAJAFI

Behrouz Aghaei[1]| Afshin Mohseni Arasteh[2]| Masoud Torabi Azad[3]| Kamran Lari[4]

[1,2,3,4] Department of Physical Oceanography, North Tehran Branch, Islamic Azad University, Tehran, Iran.

ABSTRACT

Estimating the rate of sediment and sediment transfer one of important factor that effects the design of construction in the port and coast and at present the efforts have been done for how to determine the amount and rate of sediment and their effects.In this research sediment and erosion in the port SAJAFI have been investigated that distribution of sediment in two method experimental method and numerical method for their effects highs tide and low tide effecting on the port SAJAFI.In the experimental method from decreasing and increasing of the water level for determining the process of sediment and erosion has been used.The first hydrography in 1391 (in mid-year) used as reference and base to hydrography in mid-1392 rate of sediment and erosion in accordance with border and primary condition, the result showed that there is 5.5 to 7.7 percent error when compared.Coincidence the results Mike 21 with experimental result and evaluation, showed the accuracy of this procedure and can be used as practical method to computing the rate of sediment and erosion for dredge operation in the next years.The gained result with the analyses of sediment and erosion says that in the shallow region of the coast due to velocity of the water in high and low tide the density of particlesin Water is increasing and sea current transfer them to the coast and cause erosion in shallow region and also in the region that are deafer than coastal region we see the sediment and those region next to construction.Around the region of constructions the velocity of current and tide is decreasing and potential of transferring deposit and sediment falls down and so the particles in the water settle down.

Keywords: Sajafi port – hydrography – sediment – erosion – low/high tide.

I. INTRODUCTION

The phenomenon of sediment is one of the most changes that affect the coast and the major factors with that are waves, currents, tides, wind, and topology and manmade changes on the coast. Also the cause of sediment in the one region of coast is suspension of particles of sea bed due to turbulence and wave breakdown mainly in vicinity of breakdown of waves.[1] Interactive of wave and sea current to sediment transfer is very important

one which by integration of three models winch3d and transferring model of sediment a new model "couple marine prediction system" appeared with the reasonable result and outcome.[2]

Researched in the port RIZHAO in china made in connection with computing of sediment transfer the coast which in this research showed the accuracy of Software Mike 21 based to wave parameter in determining the rate of sediment along the north and south of this port.[3]The

research in the coast of France the result showed the wave energy has direct effect in ratio of sediment along the coast.The whole sediment on the coast with the parameters of wave accident and breakdown has direct ratio and the wave height and period and wave breakdown on the whole transfer along the coast and vertical distribution on coast is of importance.[4]In regard to location of KHOMEINI port (BIK) and high and low tides have effect on rate of transfer of sediment and the way exchange of sediment on the upper section.

Software Mike 21 in modeling of sediment transfer along Astra River by using the characteristic of water wave in the shallow water to region of wave breakdown can be computed. Also in 1387 prediction of sediment rate in the gulf of PZM for dredging of channel load by surveying the water condition and geographic condition such as seabed level-current and topology had made and showed the result.[5]Also in the research by Mike 21 rate of sediment parallel with the coast in some area of south of coast computed and the results with the real amount of sediment behind the break waters and wave trap compared and the accuracy correctness of these relations in the south coast of country indicates the accuracy of Mike 21 and also is a function for computing the coefficient K in base to breakdown submitted.

II. Geographic location of SAJAFI port

Port of SAJAFI id located at region 45o43 east and 30"14' north. This port is at vicinity of ZOHRE River and 12 km faraway from Persian Gulf. Because this port is close to sea the river is influenced by the tides. In general in this port the main factor for sediment and current DB is seasonal changes and of course the precipitation and rain fall at origin of river. This river in regard to its depth is suitable for motor launch and small craft and in high tide they can go all the way close to HANDIJAN town.

Figure 1 geographical location of Port Sajafi

III. Methodology

The data and field measurement present have collected and analysis made to base of this information.

In regard to what observed in SAJAFI region and bank of ZOHREH River that is 11 km far from sea and the possible effect of river level in different season on reference level of high and low tides (may have little effect) for applying corrections to volume of water at the different season it requires long term observation and rain measurement in the field of MATSHKEH and ZOHREHRiver that takes time.[6]One of the important factors required for hydrography and sea hydro plan (MAP) is determining (chart datum).In regard to newly construction of port SAJAFIandLake of any information for this route on sea map and also lake of chart datum (CD) in relation and relative to leveling and connecting this in information to computed depth was essential.

Among the different method the best one is to monitor the tides in a specified period for one year, seasonal and at least every month and regarding to present facility for specified period for monthly manually and analyzed of gained data and information and coincided with the estuary (KHURE-MOSA) so the result was a number (tide pole) and sent to that port.Hydrography of port SAJAFI 120 km in length and 100 meter in wide in front of port SAJAFI harbor from 1391/01/02 began and ended 1392/05/01.

Figure 2 Port Sajafi Air Map

Equipment used in the research

Hydrography boat	One boat
Echo sounder	One set
DGPS	One set
Rang finder / binocular	One set
Portable computer	One set
Motor boat	One boat
Logistic boat	One boat

Processing the recorded data by the hydrography/hydrology team (from marine department) during 60 hour from 1392/05/16 to 1392/05/05 (none stop activity) after operation at sea (when ended) and after data processing that gained during this research navigation and the hydrology map that our team provided (the software surfer used for this research) the conclusion was chapter 5 and chapter 5 is the result.

Numerical Method
By using the tide model (calibrated model) and field measurement from making sediment model this modeling was used.
Model MT1 used for erosion and sediment in the region under study (MT1 is in Mike21 software packet) because the present sediment in the port SAJAFI and around are small grain type and sticky which has great effect in erosion and sediment. Spreading of such sediment has its special affect and must be consider in mathematic model.[7]

For investigating such behavior equation advection-dispersion for computing the density of sediment in any point and any step should be used.

$$\frac{\partial c}{\partial t} + V_x \frac{\partial c}{\partial x} + V_y \frac{\partial c}{\partial y}$$
$$= \frac{1}{d}\frac{\partial}{\partial x}\left(dD_x \frac{\partial c}{\partial x}\right) + \frac{1}{d}\frac{\partial}{\partial y}\left(dD_y \frac{\partial c}{\partial y}\right)$$
$$+ \sum_{i=1}^{n} \frac{s_i}{d_1}$$

Sedimentation
Sedimentation phenomenon happens when sea bed cutting stress is lesser than critical stress for deposition.[8]
Rate of deposition of sediment with the regard to speed of fall down is computed and computed as follow:

$$R_D = W C_b P_d$$

Erosion
If applied cutting stress to sea bed id greater than critical stress for erosion, grain and particles of sediment at the sea bed erosion will happen. Rate of erosion for the hardened and compressed sea bed fin out as follow:

$$R_E = M\left(1 - \frac{T_b}{T_{ce}}\right)^n$$

spreading coefficient D_x and D_y

$$D = K \Delta X U$$

Spreading coefficient determines the rate of spreading around a definite point which in model MT by using the relation between current speed or equation of network dimension numerical solution is gained determined.

Characteristic of numerical model and primary condition
a) Determining type and density of sediment at lab
84 samples taken from suspended sediment in depth close to surface-close to sea bed depth and in depth middle close to sea bed. Physical parameter (current speed, direction, salinity, temp, pressure, density ...) cached per hour.
By the vacuum pump, filter paper, analytics scale with accuracy of 0.0001 and graduated cylinder for duration of one week in every season and the amount of density in each station ascertained for each sample and then by local averaging and time averaging rate of sediment density determined.
Important factor in transferring carrying of sediment and deposition in each season in river.
Type of sediment material in the SAJAFI port in the view of their behavior in the math model is very important and coastal current region, is the

most important in determining the pattern of sedimentation and erosion.

Table 1Lab result about type and density of sedimentation

Sample name	Graved	Sand	Silt	Mud	Special gravity gr/cm³	Fluidity	Paste limit %	Y Longitude	X Latitude	Sample code
Slit	0	5	67.5	27.5	2.65	15.88	30.52	3327004	36.112	S11

Coefficient of erosion (M) and cutting stress limit of erosion and deposition τ_{ce} and τ_{cd}

Determining these parameters for computing rate of sediment and erosion it is required that coefficient of erosion equal to g/m²s 0.02 be considered in math model used.

Cutting stress of erosion limit and sediment in regard to valid comment corresponding to the below is selected

Selected amount N/m²	Recommended limit N/m²	parameter
0.01	0.005-1	Stress cutting limit of sediment
0.1	0.06-1	Stress cutting limit of erosion

Table 2:

b) ZOHREH River as fountain in modeling

For analyze of hydraulically phenomenon in the mouth of river characteristic of current and sediment enters to river must be ascertained.

In this model the out flow of ZOHREH River is used as source input to the model for finding out river DB (DB sediment).

The past 30 years statistic of DEHMOLA hydrology station that is the closest station to mouth of river is used in this model. In the mouth of ZOHREH river point (120.495) used as input of model and in regard to present statisticaverage DB of the river is 89 m³/s is regarded.

c) Equation between current and sediment DB of river

Normally the different between DB of current and sediment in a river an equation can be written. This equation for ZOHREH River by using DEHMOLA hydrography station is gained in Excel.

Regarding to relation between current DB and sediment in fountain density model consider to be 988 gr/m³

d) Time step

Time step for solving the equation is of type to keep its model consistency. Time step 10 second and currant figure is 6.

IV. DISCUSSION AND RESULT

Transfer rate of sediment due to high and low tide current in the experiment method after entering parameters used in solving the prevailing equation. The program done and their gained results are from the model in which the output used are from rated of sediment and erosion.

Table 3Rate of sediment transfer due to high and low tide from experimental model

Phenomenon	Sediment transfer cubic meter (92-91)
Sedimentation	5485.135
Erosion	4601.365

1) In regard to studied investigation done in the complete cycle of low-high tide it can be said tides with the deposition of river have direct relation but with the transfer of sediment has inverse relation.

In the low tide current because sediment and deposition are in the same direction with the river more transportation with happen.

2) Rate of sediment transportation due to tides in the Mike 21 software. The result of determining rate of sediment per year by using Mike21 which is the resultant of sediment density in one year is show in below table. It shows the whole rate of deposition equals to 5930.5 m³ per year and the whole amount of sediment transport equals 4371.9 m³ in a year. So the net amount of deposit due wave in the region of case study is around 1558.6 m³ per year.

Table 4 Rate of transportation due to wave (tides) from Mike21 software

Phenomenon	Sediment transportation m³ (92-91)
Sedimentation	5930.5
Erosion	4371.9

3) Computing error of numerical model with numerical model

In the above tables rate of transportation of sediment due to wave of tides (low/high) is

evaluated by two software Mike21 and experimental in cubic meter.

By comparing the data rate of erosion and sediment in numerical model and experimental model computation of percent of error in numerical model is studied. The amount of error 5.5 to 7% found out.

The percent of error for deposition based to the lab data and numerical model is as follow:

$$Error_{ratio} = \frac{|Q_{modeling} - Q_{expriment}|}{Q_{modeling}}$$

After adding the gained result of software Mike21 and experiment, below is the rate of error for erosion and deposition.

Table 5 rate of error for methods of experiment and CERC

Phenomenon	Rate of error
Sedimentation	7.5%
Erosion	5.2%

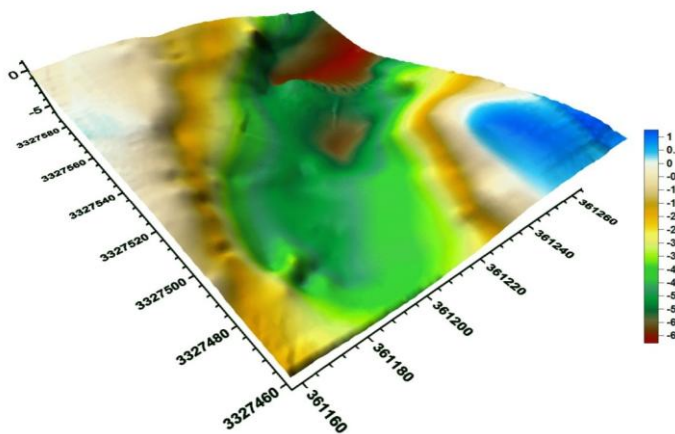Three dimensional hydrography profiles for SAJAFI port

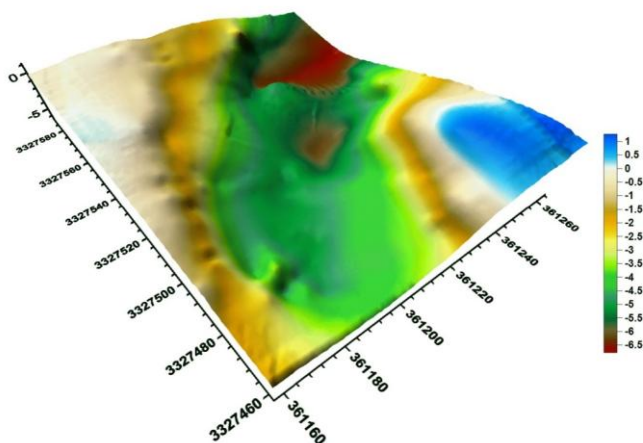Figure 3 Hydrography MAP (3D) for SAJAFI port (1391)

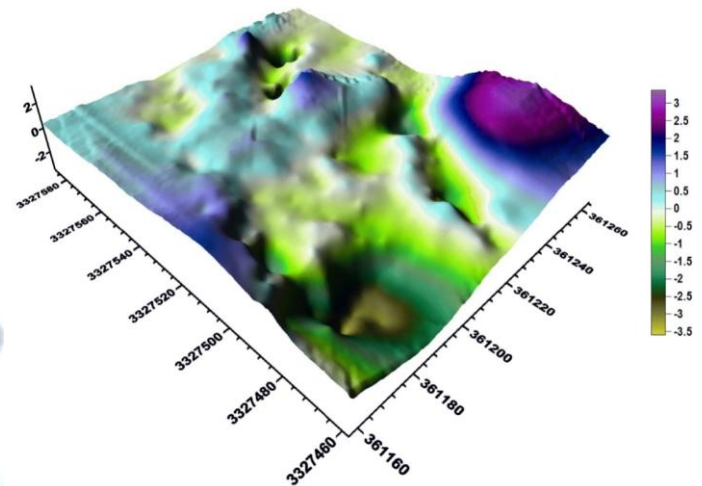Figure 4 Hydrography MAP (3D) for SAJAFI port (1391)

Figure 5 transportation of sediment annually (92-91)

In SAJAFI port (the negative value for erosion and positive for rate of deposition)

V. CONCLUSION

1- By comparing the result of Mike21 with the experiment method rate of error for deposition is around 7.5 percent and for erosion is 5.2 percent.

2- The gained result which is compared with the veiled experiment method says that Mike21 is accurate one. So it can be used as a practical method for estimating the deposition and erosion and this software is accurate for next years and dredge operation.

3- During high tide current because of different in direction with the river, water DB is increase and large volume of water is in turbulent and causes the sediment in form of suspension. In so doing, the sediments have time and deposit.

4- In the low tide current, because it has the same direction with river rate of sediment transportation is increased.

5- Regarding to gained result in complete cycle of tides, can say low and high tides have direct relation with the deposition but indirect with sediment transferring.

6- During high tides, currents after passing the bay of SAJAFI port, follow the west and North West direction of local model. These currents effects the wide intervals of ZOHREH River so with field observation effect of high tide in ZOHREH River can be view to HANDIJAN town.

7- During the low tide in coastal region because of shallow depth, current speed increase and causing suspension of sediment particles and low tide current toward west of model after passing outgrowth in the east region of study, becomes

parallel in which causing more suspension of sediment particles.

8- during high tide, the width of high and low tide is toward the sea water and these high tide currents supports the cutting stress required for suspension of sediment particles.

9- In high tide condition current velocity reduces due to striking to construction, so in comparison with low tide current velocity in shallow water reduce so in high tide because the lack of supporting of cutting stress for sediment suspension, sediment material and material density is less than the low tide.

10- In the coastal shallow water because of high current velocity in both high and low tides the density of suspended particles increase and these current carries these particles and causing erosion in shallow water and by transportation of suspended material at region that are deeper than coastal region we encounter with deposition.

11- region around construction we see deposition, around construction velocity of tides reduce and by reducing velocity, potential of sediment transportation reduce, so the suspended sediment have enough time to deposit at these regions.

REFERENCES

[1] Goda Y., 2001. A new approach to beach morphology with the focus on suspended sediment transport. Proc. 1st Asia and Pacific Coastal Engineering, pp. 1-2

[2] Li Ruijie, 2008. Numerical Study on Deposition in Rizhao Port. Technical Report. Research Institute of Coastal and Ocean Engineering, Hohai University, pp. 30-36. (in Chinese)55 – 76.

[3] Trebossen H_., Deffontaines B., Classeau N.,2005, Monitoring coastal evolution and associated littoralhazards of French Guiana shoreline with radar images . Journal_of C. R. Geoscience 337 (2005) 1140–1153

[4] Anıl Ari H., Determination and control of longshore sediment transport.2006, Journal of OceanEngineering.224-238

[5] Abaee, h., Evaluate the sediment transport in Imam Khomeini Port, MA thesis,1997 Islamic Azad University, North Tehran Branch.

[6] Mohandesi Namin, Investigate the sedimentation basin upstream and downstream of Bndrastarav erosion, water research center affiliated to the Ministry of Energy.2004.

[7] Ebrahimi, R., Evaluation and calibration methods long shore sediment transport formulas related to the coastal area of the Gulf cook,2009. MA thesis, Islamic Azad University, North Tehran Branch.

[8] Afshar, N, Sultanpur, K., Validation of longshore sediment transport in some of the southern coast of Iran, 2010.MSc thesis, Islamic Azad University, North Tehran Branch