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THE CALCULATED RESULTS OF CURRENT FIELD AND ITS EFFECTS ON THE PROCESS OF SEDIMENT TRANSPORT AT DONG BO RIVER MOUTH (CUA BE), NHA TRANG

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ABSTRACT In dry season, the calculated results for a tidal phase (from 11h/28/4 - 11h/29/4/01) showed that the maximum velocity of the currents was 37 cm/s in ebb-tide phase and 28 cm/s in flood-tide phase. The movement of bottom materials was not considerable, about 1 m^3 of bottom materials run out from the study region.

In rainy season, in the tidal period (from 23h/4/11 – 23h/5/11/01), the current field was stronger than that in dry season with maximum values of velocities of 100 cm/s and 27 cm/s, in ebb-tide and flood-tide phases, respectively. There was about 10 m^3 of bottom materials running out from the region. The maximum erosion rate was 380.10^{-4} m per 24 hours (tidal period) and the maximum deposition rate was 210.10^{-4} m per 24 hours.

CAC KET QUA TÍNH TRÖÔNG DONG CHAY VA ANH HÖÔNG CUA NO LEN QUA TRÌNH DÒCH CHUYEN TRAM TÍCH KHU VÖC CÖA SONG ÑONG BO (CÖA BE), NHA TRANG

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TOM TAT Trong mua kho, cac ket qua tính cho mot chu ky trieu (tö 11h/28/4 – 11h/29/4/01) cho thay: toc ño dong cöc ñai la 37 cm/s trong pha trieu rut va 28 cm/s trong pha trieu len. Qua trình di chuyen vat lieu ñay la khong ñang ke. Co khoang 1 m^3 vat lieu ñay bò di rôi ra khoi khu vöc nghien cöu.

Vao mua möa, cho mot chu ky trieu cu the (tö 23h/4/11 – 23h/5/11/01) ket qua tính chæ ra rang tröông dong chay manh hôn trong mua kho. Toc ño dong cöc ñai vao pha trieu rut la 100 cm/s va pha trieu len la 27 cm/s. Toc ño xoi cöc ñai ñat 380.10^{-4} m sau 24 giô tính va boi cöc ñai la 210.10^{-4}m. Co khoang 10 m^3 vat lieu bò ñöa ra khoi khu vöc nghien cöu.

I. INTRODUCTION

Located at southern Nha Trang City (Fig. 1), Dong Bo river mouth is a region having many economical activities. One fishing port, one shipbuilding yard and many residential areas are located in a length of only two kilometers along the right riverbank. At the left riverbank, a residential area is in construction and a fishing port is going to be built in the next time. The studies on the current field and its effects to the change of the river bottom topography are necessary. This paper deals with the effects of current field on the movement ability of the bottom materials.

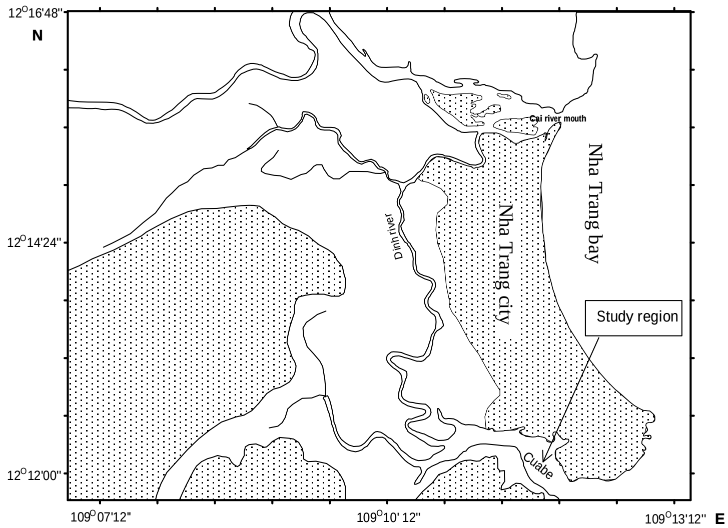

Fig. 1: The study region

II. MATHEMATICAL MODEL

1. Currents [5]

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+g\frac{\partial H}{\partial x}+F_x-\Omega.v=0 \quad (1)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+g\frac{\partial H}{\partial y}+F_y+\Omega.u=0 \quad (2)$$

$$\frac{\partial H}{\partial t}+\frac{\partial}{\partial x}(u.(H+D))+\frac{\partial}{\partial y}(v.(H+D))=0 \quad (3)$$

$$F_x=\frac{g.u\left|(u^2+v^2)^{1/2}\right|}{C^2(H+D)} \quad (4)$$

$$F_y=\frac{g.v\left|(u^2+v^2)^{1/2}\right|}{C^2(H+D)} \quad (5)$$

2. Equation of bottom elevation change [2]

$$\frac{\partial z}{\partial t}=-\frac{\partial}{\partial x}\left(q_x-\varepsilon_s|q_x|\frac{\partial z}{\partial x}\right)-\frac{\partial}{\partial y}\left(q_y-\varepsilon_s|q_y|\frac{\partial z}{\partial y}\right) \quad (6)$$

3. Sediment transport due to a mean current [2]

$$q_x=Q_c.u; q_y=Q_c.v \quad (7)$$

$$Q_c=\frac{A_c.(\tau-\tau_{cr})}{\rho.g} \quad (8)$$

In which:

- x, y: two orthogonal horizontal axes
- u, v: velocities in x, y directions
- H: elevation of the water surface above a fixed horizontal plane.
- D: depth of the bed below the same fixed plane
- F_x, F_y: friction terms in x, y directions
- Ω.v, Ω.u: horizontal components of Coriolis force
- z: the change in local bottom elevation
- τ: Maximum value of the bottom shear stress
- τ_{cr}: the critical shear stress for the onset of sediment movement
- ρ: Density of water.
- g: the gravitational acceleration.

These equations are commonly used, so in this paper their details will not be dealt with.

4. Boundary conditions

Solid boundaries: the component of the current in the normal direction is zero.

Free boundaries: H - oscillation of water level caused by the tide recorded as follows:

Recorded water level on 28 - 29/4/2001 in case of dry season (Fig. 2), and on 4 - 5/11/2001 in case of rainy season (Fig. 3).

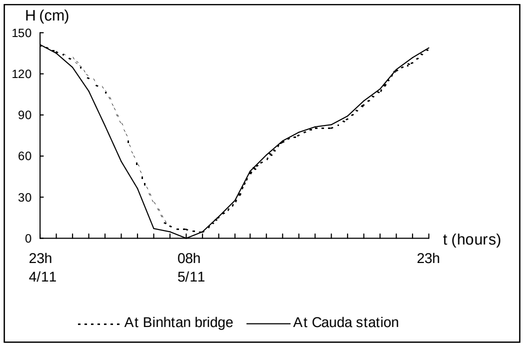

Fig. 2: Recorded water level at Cau Da station and Binh Tan bridge on 28 –29/4/2001

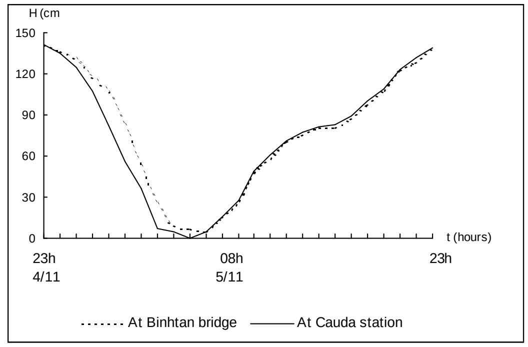

Fig. 3: Recorded water level at Cau Da station and Binh Tan bridge on 4 –5/11/2001

5. Initial conditions

t = 0;   u = 0;   v = 0;

z = 0; H = 0.

The equations of the currents and the change of bottom elevation were solved by different method.

The calculated region is divided into grid cells with spacing of each cell of 50 meter in x-direction and 100 meters in y-direction. The time step is 2 seconds. The bottom topography, input of the model was surveyed in March 2001 (Fig. 4).

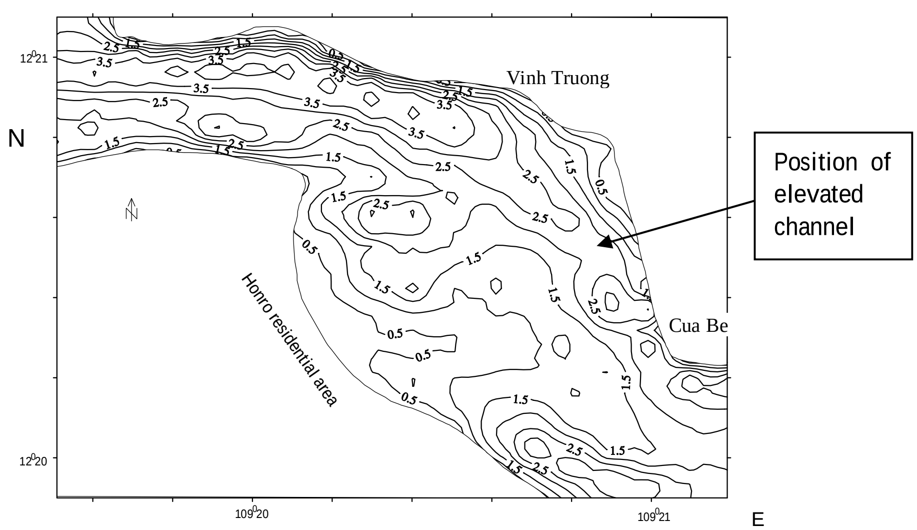

Fig. 4: The bottom topography of Cua Be region (surveyed on 4/2001) (number on the contour: m)

III. THE CALCULATION AND STUDY RESULTS

The total length of the calculated region is two kilometers. The width of the river is 550 meters (at the outside free boundary) and 300 meters across Binhtan bridge (the inside free boundary). The maximum width of the river is about 900 meters. The river is rather shallow with maximum depth of about 5 meters. The relief of riverbed is unsymmetrical with the channel running closely to the right bank. A warp with area of 28,000 m^2 expanding at the central part of the study region makes the riverbed shallower. This causes the elevation of channel at the right edge of the warp (Fig. 4).

The bottom materials in the study region are quartz sands. Median diameter of grains is 0.15 millimeters. The calculated results show that the critical current velocity making bottom materials to begin movement is 20 cm/s Some calculated results of current field and transport of the bottom materials are as follows:

1. In dry season

1.1. In ebb-tide phase (from 11h/28/4/2001 to 20h/28/4/2001)

The currents: the flows run from the river to the sea with the maximum velocity of 37 cm/s at 16h/28/4/2001. At the place of elevated channel (Fig. 4), the currents reached to the values of more than 20 cm/s. Most velocities of currents in the study region were about 10 – 15 cm/s. (Fig. 5).

The transport of bottom materials: the movement of bottom materials was not considerable. It just happened from 15h to 19h/28/4/2001 at the area of the elevated channel.

1.2. In flood-tide phase (from 20h/28/4/2001 to 11h/29/4/2001)

The currents: the flows mainly run from the sea to the river. However, the velocities of the currents were less than that in ebb-tide phase. There was still a high velocity center of the currents around the area of the elevated channel. The maximum value of the velocity was 28 cm/s at 5h/29/4/2001 (Fig. 6).

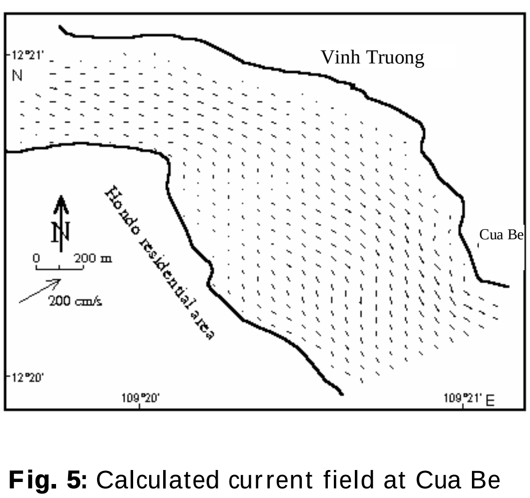

Fig. 5: Calculated current field at Cua Be (16h/28/4/2001)

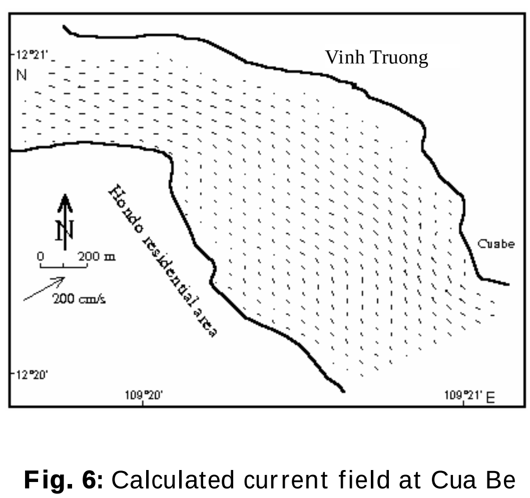

Fig. 6: Calculated current field at Cua Be region (5h/29/4/2001)

Sediment transport process: in the flood-tide phase, the materials were transported in the direction contrary to that in the ebb-tide phase. The sediments at the places of deposition in the ebb-tide phase were taken and deposited at places of erosion before. However, in the dry season, the current field was weak, so the movement of materials was not considerable.

In the tidal period (from 11h/11/5/2001 to 11h/26/5/2001) there were about 1 m^3 of materials moving out of the calculated region. The maximum rate of erosion was $4.9.10^{-4}$ m per 24 hours (tidal period) and the maximum rate of deposition was $3.6.10^{4}$m per 24 hours. The changes of elevation of bottom topography is shown in figure 7.

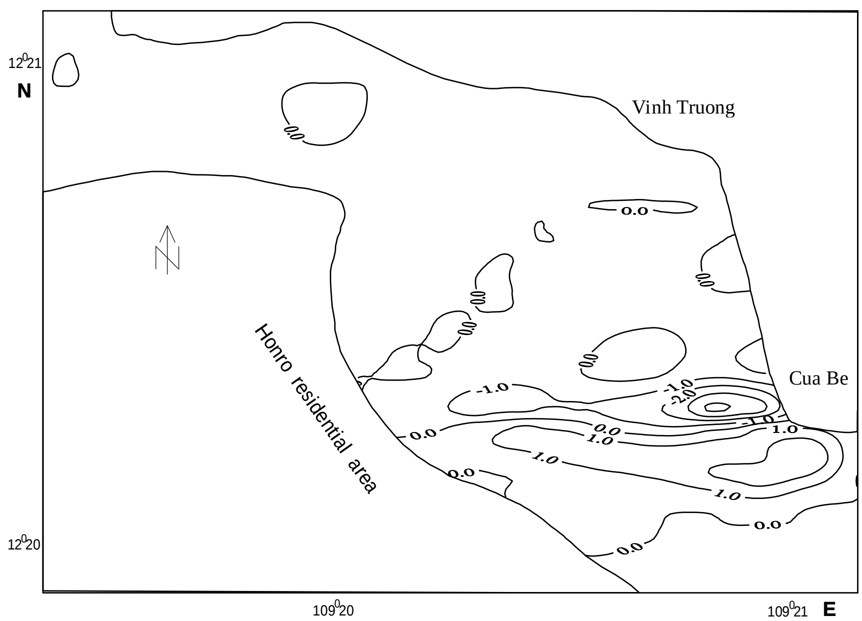

Fig. 7: The changes of the elevation of bottom topography in a tidal period of 24 hours in dry season (unit on the contours:10^{-4} m/24 hours)

2. In rainy season

The calculated results of the current field from 23h/4/11/2001 to 23h/5/11/2001 are given below.

2.1. In ebb-tide phase (from 23h/4/11/2001 to 8h/5/11/2001)

The currents: in the rainy season, the velocity of the current at Cua Be was rather high because of the heavy rainfall. The distribution of current field in the direction was similar to that in the dry season (from the river to the sea). However, velocities of the currents were higher with the maximum value of 100 cm/s at 4h/5/11/2001 (Fig. 8).

Sediment transport process: the movement ability of materials was increased because of the strong currents. The calculated results are shown in table 1.

Table 1: Some calculated results of the change of bottom topography in rainy season, ebb-tide phase

Calculation time	Erosion – deposition speeds			
	Maximum (m)	Minimum (m)	Average (m)	Volume of changed materials (m^3)
From 23h/4/11 to 1h/5/11	$+1.70.10^{-4}$	$-2.80.10^{-4}$	$+1.50.10^{-6}$	+2.08
From 23h/4/11 to 3h/5/11	$+4.68.10^{-3}$	$-7.01.10^{-3}$	$+1.15.10^{-5}$	+15.98
From 23h/4/11 to 5h/5/11	$+1.58.10^{-2}$	$-2.64.10^{-2}$	$+5.20.10^{-7}$	+0.72
From 23h/4/11 to 8h/5/11	$+2.10.10^{-2}$	$-3.87.10^{-2}$	$-6.37.10^{-6}$	-8.85

Notes: + deposition; - erosion

The calculated results showed that at the end of ebb-tide phase, there were approximately 9 m^3 of materials running out of the calculated region.

2.2. In flood-tide phase (from 8h/5/11/2001 to 23h/5/11/2001)

The currents: the current field in the flood-tide phase was reduced both the module and time of running because of the effects of fresh water. The maximum value of velocity was 27 cm/s at 19h/5/11/2001 (Fig. 9).

Sediment transport process: because of the weak current field, the movement ability of the materials was low and just happened in some places. The loss of materials was more than 1 m^3.

In the whole tidal period (from 23h/4/11/2001 to 23h/5/11/2001), there were about 10 m^3 of materials moving out of the calculated region. The maximum erosion rate was 380.10^{-4} m per 24 hours, and the maximum deposition rate was 210.10^{-4} m per 24 hours.

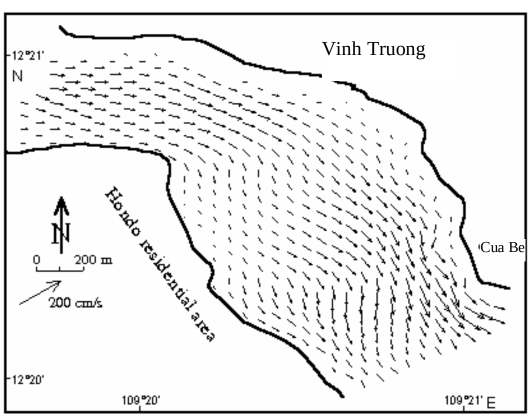

Fig. 8: calculated current field at Cua Be (4h/ 5/11/2001)

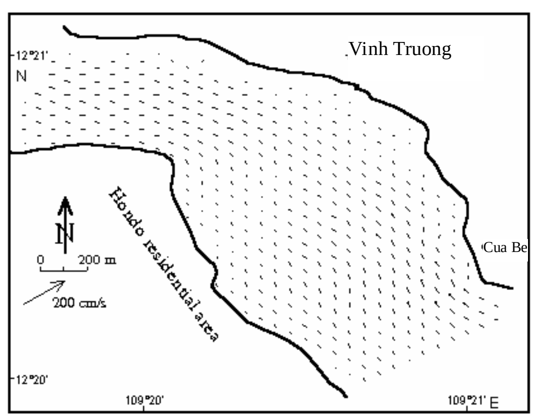

Fig. 9: calculated current field at Cua Be region (19h/5/11/2001)

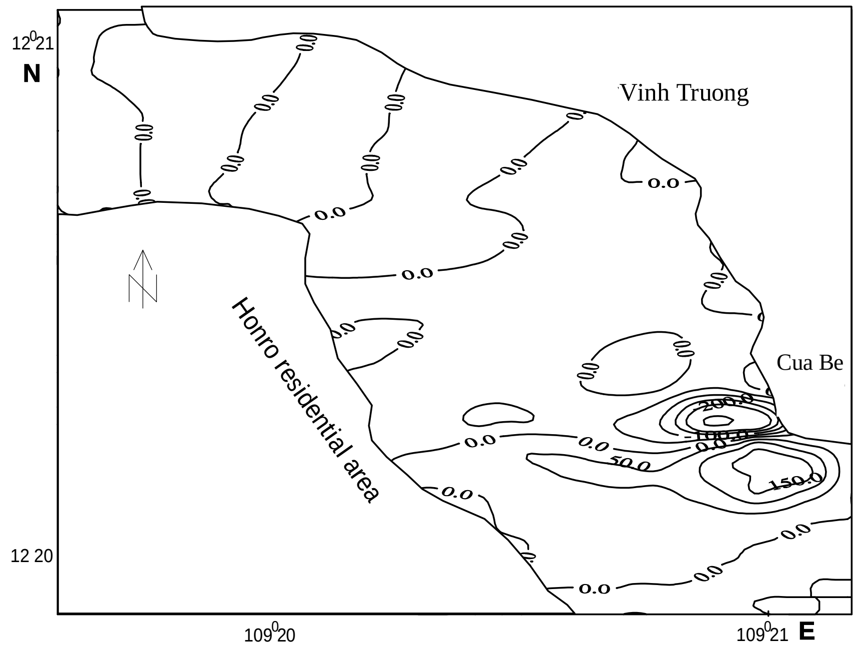

Fig. 10: The change of the elevation of bottom topography in a tidal period in rainy season (unit on the contours: 10^{-4} m/24hours)

The calculated results are shown in figure 10.

IV. CONCLUSIONS

The bottom materials in Cua Be are mainly quartz sands with median diameter of 0.15 millimeters.

Critical current module making sediment to move is about 20 cm/s.

The calculated results showd that:

- In case of dry season, from 11h/28/4 to 11h/29/4/2001, the maximum values of current module were 37 cm/s in the ebb-tide phase, and 28 cm/s in the flood-tide phase. There were about 1 m^3 of bottom materials running out of the calculated region.

- In rainy season, from 23h/4/11 to 23h/5/11/2001, the maximum velocity of current reached to the values of 100 cm/s in the ebb-tide phase and 27 cm/s in the flood-tide phase. The loss of bottom materials was 10 m^3.

- The effects of erosion and deposition processes to Hon Ro residential area and the left bank where a new fishing port is going to be built were not considerable.

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