

ON THE SEDIMENTATION AND EROSION ON HUONG RIVER SEGMENT CROSSING OVER HUE CITY

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Abstract: Hue City is a world cultural treasure and one of Vietnam's well-known tourism centers. The unstable water flow has caused erosion and sedimentation belong to both Huong river banks, specially on the river segment crossing over Hue city which are problems must to be controlled for returning wonderful spectacle of Hue, a small pretty city in the middle of Vietnam Country.

The study is carried out with many difficulties in collection of hydrological data, it seems that up to now, there were almost no survey works on sedimentation and erosion of the Huong river. Therefore the study results is setting up the base of continuous studies on the progress of the river. Base on the surveyed data and calculation, the software to treat and control all collected data of elevation measurement and topographical map production of riverbed have been built up, the present of sedimentation and erosion occurred in the Huong river segment crossing over Hue city and its consequences has been described preliminarily, then withdrawn some suggestions on the main solutions for minimizing sedimentation and erosion.

Key words: Sedimentation, erosion, riverbed.

1. Introduction

The sedimentation and erosion processes have long been of interest in the field of morphology to investigate the changes of riverbed and bank erosion with the flow regime. Studies of those processes have contributed greatly to our understanding of the relationship between river revolution process and water flow as well as socio-economic activities on the river basin. In recent years, many researches on the modelling of sediment transportation in the river has been composed, and most of them focused on the problems in the larger river systems such as Red river or Mekong river but there was very few ones focused on the rivers in the Middle of Vietnam.

Although modelling is now becoming the very cheap and effective method to study and forecast the hydrological processes but we also need to investigate the actual situation as well as to measure real data using for calibration and verification of the models, and topographical data are needed to input of the models during running on.

Hue city is a world cultural treasure and one of Vietnam's well know tourism centres. For a long period, an unplanned development unsuitable land and water use of the catchment area and management of socio-economic activities has caused pollution and detrimental impacts of the environment in which deterioration of Huong river became serious matter of landscape of Hue city. The unstable water flow has been causing erosion and sedimentation belong both riverbanks, specially on the segment crossing over Hue city which are problems must to be controlled for returning wonderful spectacle of Hue.

The objectives of erosion and sedimentation survey on Huong river segment crossing over Hue city are to prepare a report in which, it is needed to review and collect documents related to variability of flow as well as erosion and sedimentation aspects on the Huong river. Then in order to get the picture of the actual riverbed conditions in the segment crossing over Hue city, and access the real state of riverbank we need to build up a topographic map of the segment from Van Nien to Bao Vinh. Base on these results and discussions we propose application techniques for minimizing detrimental impacts of water flow to social economic aspects of Hue city.

2. Materials and methods

Instrumentation:

A sounder FURNO 4300 was used to aid the measurement of water depth from 1.5m to 350m. The geographical co-ordinate was conducted and recorded using the GPS equipment GARMIN II with the random error is around 40cm horizontally. The scanner HP 3200 with the resolution of 300 dpi was used to transfer the paper graphs into digital one.

Preliminary field surveys:

This is the initial survey to select the general line for implementation. The main features to be decided are:

- Selection of main objectives a long the river for observation lines.
- Identification 3 lines (left, right and middle of cross- section) up and down of the river segment for measuring topography for longitudinal section.
- Selection of 100 positions for measuring river horizontal section.

Measuring method:

The topography of the riverbed was presented through out the elevation of many points within the studied area. The elevation of the riverbed at each point was defined as the difference between the water level and the water depth simultaneously. Using the FURNO 4300 sounder to observe the water depth in

combination with the water level and measurement of position of that point (recorded by the GPS equipment).

Data treatment method:

The output of the FURNO 4300 is the paper graph presenting the changing of the water depth with the distance from the survey marker (Fig 1.1 is an example). Firstly, these graphs were scanned into the images then were automatically digitised and treated by computer running in Pascal language (App. 1) to get the actual water depth at each point in the longitudinal and cross sectional. Then it was used to produce topographical map of Huong river bed by using a map software.

The contour line of topographical map were drawn at contour interval of 0.5m level on the base map with 1:5000 scale and are obtained by interpolation from nearest design contour and the reference contour line. After joining and smoothing contour lines write its values on the map according to the determined regulation.

3. Results and discussion

Topography of horizontal cross-section

To study the topography of Huong river cross-section from Van Nien to Bao Vinh, based on the variability of Huong river bed topography the full segment was divided into 5 sub-segments with differences in bed topography and influence to stability of flow rate as:

- 1 - From Van Nien to 1 km upward Xuoc Du bridge
- 2 - From 1 km upward Xuoc Du bridge to Thien Mu pagoda
- 3 - From Thien Mu pagoda to pre-site of Con Hen area
- 4 - Subsegment passing Con Hen area
- 5 - After Con Hen to Bao Vinh

- The cross-section of the first sub-segment is parabolic form with the main hydrodynamic channel is located at right of the current (Fig. 1). It is to be seemed that erosion and sedimentation haven't occurred along both borders as at the riverbed in the sub- segment.

- The second cross-section of the sub-segment is triangular form with its top at the bottom, which is near the left border. The main hydrodynamic flow was declined to left side and an eddy current was formed also along the left side (Fig. 2). Heavy erosion has occurred on the left border especially in flooding and rainy season. An annual average of 5-10 m of the bank was eroded. In comparison with the current of 10 years ago, the river sub-segment has transferred to the left side a distance about 70- 80m. A erode usually was formed along left side at water depth from 11m to 19m. The eroded soil was brought to the opposite side and a very large water deposited soil was formed along the right side of sub-segment. This situation makes

the sub-segment gradually suffered from heavy curvature and the river will undergo great change of current direction.

The down stream of the river may be become a "stagnant water area" which will cause a detrimental impact on environment and landscape of Hue city.

- The third sub-segment is observed into 15 cross-sections (Fig. 3). The flow is steady. A water depth from 5m to 10m is found across the section of river. No bed erosion and sedimentation are found there. But the Gia Vien fixed dune has emerged at right border, near Bach Ho bridge and by which the flow rate is arrested and accumulated sedimentation at the river bed is found. The sub-segment runs across Hue City with both sides were built up with stone thus no border erosion was found. But runoff discharged from smaller inflow at the left side of the river into this segment, which has brought also sedimentation materials. It can be seemed clearly that the most cross-section are rather flat with average water depth of 4- 5 m and sedimentation was distributed on all area of the river bottom. But at the cross-section before and after Bach Ho, Trang Tien, Phu Xuan bridge, there are a bed slope from left to right side with depth water of 7-8m. In general, river bottom erosion does not happen and sediment availability on this section is very high and the main hydrodynamic flow occurred unclearly.

- All cross-sections of the fourth sub-segment is rather flat (Fig. 4) with depth water of 3-4m. This is an area having heavy sedimentation caused by the branching flow off and small flow rate. In addition, in dry season, the segment is tided up, salt water also created favourable condition for sedimentation on the river bottom.

- Cross-sections of the last sub-segment has the average depth of 3-7m and its bottom slope runs left to right border with the water depth varies from 3 to 6- 7m. This segment has the cross- section was very narrow thus the flow rate increased and bed scouring was occurred. At down stream of the bend, there is about 600m of length of the right side was strongly eroded causing by hydrodynamic channel passing bend area. It can be seen on cross- sections in Fig. 5, Fig. 6.

Topography of longitudinal section

We have investigated 3 longitudinal sections of the river segment. The first is from Bio Vinh to Van Nien (16.27.711N and 107.34.669E to 16.25.73N and 107.333288E) along left side that is far from the border about 20-30m. The second section was determined in the middle of the current and begin from Van Nien (16.25.700N and 107.33.264E) to Bao Vinh (16.29.760N and 107.34.640E). The third section was defined along the right side far from the shore about 20-30m from Bao Vinh (16.29.740N and 107.34.675E) to Van Nien (16.25.761N and 107.33.620E). The results from the water depth measured line on the longitudinal section have shown that different sedimentation and erosion level were occurred in the dryer segment.

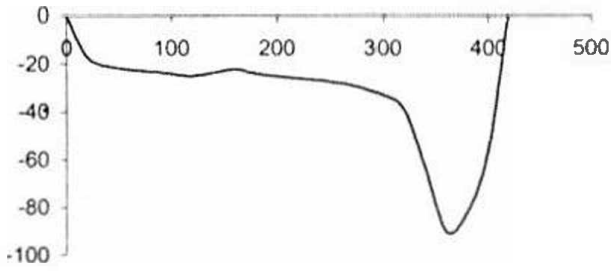


Fig. 1. Typical cross-section of the first subsegment

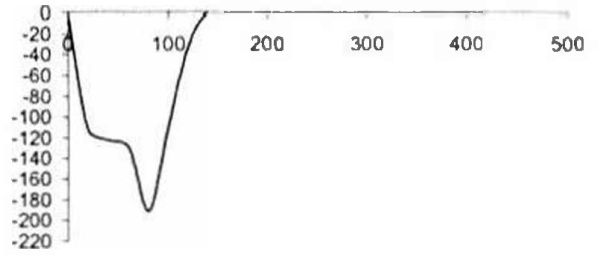


Fig. 2. Typical cross-section of the second subsegment

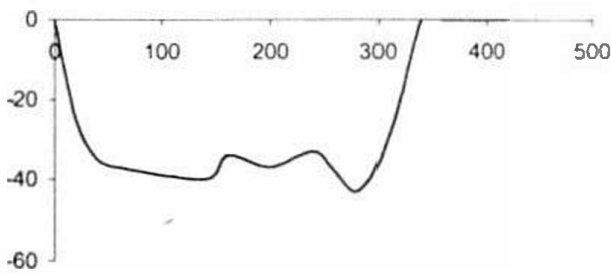


Fig.3. Typical cross-section of the third subsegment

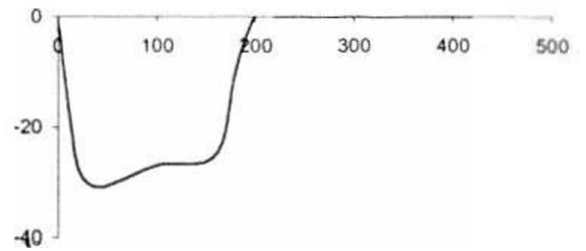


Fig.4 Typical cross-section of the fourth subsegment

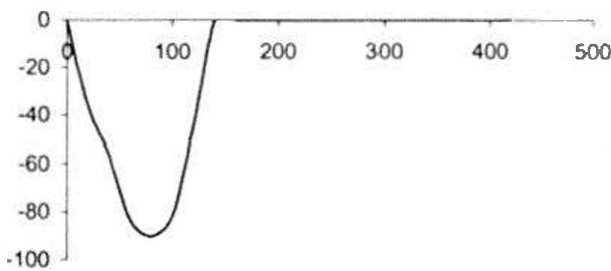


Fig.5 Typical cross-section of the last subsegment

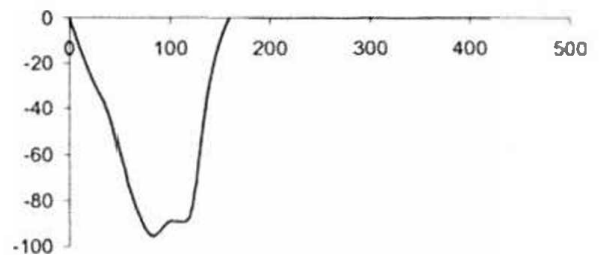


Fig.6 Typical cross-section of the last subsegment

On the base of 3 longitudinal sections and from depth measuring data, some remarks of topographical changes could be presented as follows:

- Section from Van Nien to Xuoc Du Bridge. The bed topography does not change accidentally on the 3 vertical cross-sections. The depth of river varies from 3 to 6m with the deepest runnel in the middle. It was found at the bottom some short sand wave.

- Section from Xuoc Du bridge to Thien Mu pagoda. It is the most typical eroded section of the segment. For example at left side there is an unstable

longitudinal section, the water depth, which is far from the border of 20-30m varies from 5 to 8m and at Xuoc Du bridge up to 17m. It is showed that scouring process is happening and will be continue at serious level. The bed topography is rough along the right side and the middle of vertical cross-sections. So, the left side of the river section must be paid many attention of investigation in detail to find out the best solutions.

- Section from Thien Mu pagoda to Con Hen. The longitudinal section varies with the depth from 4 to 7m. However, there are an immersed dune at bottom before Bach Ho bridge and a big dune immersing between Phu Xuan and Trang Tien Bridge and do not find out the main hydrodynamic channel of the current.

- Section passing Con Hen area. 3 longitudinal sections of Con Hen area are similar. The shallow water depth of 2-3m is much lower than that of up and down river section. It is proved that the section having the favourable conditions for sedimentation. It can be found that factors causing sedimentation were acted in the same type and spreaded over the river bed section.

- Section after Con Hen to Bao Vinh. Topography of longitudinal section varies with water depth from 5 to 11m and the bottom slope to the down stream. Hydrodynamic channel is in the middle of the current. The vertical cross-section of right side is unstable due to little erosion has occurred along the side.

Bottom topography

According to Huong River bottom topographical map with scale 1:5000 there are about 70% of the river bed area from Van Nien to Bao - Vinh at an elevation of 3-5m water depth. The maximum depth is 19.8m at the cross-section MC19 (near Xuoc Du bridge). Generally in the studied river area, the deposition of sediment was dominant. It could be divided into 4 areas for this river segment.

The first is from Van Nien to 1km upward Xuoc Du bridge. The bottom topographical map showed that the riverbed is steady. The water line of maximum depth is distributed near the middle of the current. The geological foundation of this section is quite durable. Therefore, there are high stability of flow rate.

The second is from 1km upward Xuoc Du bridge to Thien Mu pagoda. It is the deepest area and its bottom topography greatly specially in the curvature section near Xuoc Du bridge. (before Xuoc Du bridge 1.5 km and behind 1 km). The bottom topography of the area varies from 2.9 to 19m. Therefore, the hydrodynamic channel goes to the left side and cause heavy erosion at the side with distance of more than 2km. Eroded soil was brought to the opposite side and a very large alluvial ground was formed along the right side which has caused the change of direction current of this river segment. A eroded gully was formed along the left side at water depth from 11 to 19m. It can be seen that the current of this segment has transferred to the left side about 70-80m when comparing with topographical

map established in 1986. The section along Thien Mu pagoda area is influenced by mountains system at left side of the river, so that the hydrodynamic channel has gone to left side and there are also a runnel at river bottom with depth up to 8.5m. From there to the down stream of this section the river flow is more and more steady.

The third is from Thien Mu pagoda to Con Hen area. The bottom topography of the section is quite flat. Most bottom topography has elevation difference of 2-4m. With the length of 500m before Gia Vien dune, the difference of bottom topography is from 2-3m, which is easy to create floating dune in dry season. At left side near Bach Ho bridge has a runnel with depth of 5 to 7m. However, a small sand dune has been established and is running gradually to the North. Sedimentation also formed in area surrounding Phu Xuan bridge. It created immersed dune at the bottom with size as large as Gia vien dune. In general, this area needs scrape for creating the hydrodynamic corridor which is necessary for protection of sedimentation and maintaining stability of the flow rate, for pushing up eroded material at bottom river to the down stream and maintaining the navigation channel for ships and other socio-economical activities on the river in dry season.

The area from Con Hen to Bao Vinh has a topographical difference of the bottom which fluctuate between 4.5 and 8m of water depth. Because of narrow horizontal cross-section in this curvature section the flow rate is increased and the river bottom was eroded. The hydrodynamic channel in the middle of the current and flow rate is quite steady.

Some main solutions to minimize sedimentation and erosion of the river segment

Huong river has related with Hue old city during its development period. The protection of Huong river is also the protection of Hue city, so that it is essential to develop effective practices in order to prevent and overcome environmental consequences. Integrated practices of all aspects such as science and technology management options, environmental education are necessary for solving this problem. In this report, some main solutions were proposed to solve sedimentation and erosion in the studying river segment, such as:

- Rebuilding the flow direction of curvature section at Xuoc Du bridge for rehabilitating steady state of the current by building stone spur systems at the left side of the river at the site of 2-3 km before Xuoc Du bridge. It is necessary to build stone spur systems with the spur length of 30- 40m and separating each other about 50-70m. The spur must be high enough to prevent water leaving of Huong river in the flooding season. The stone spur systems maintain the steady flow for preventing a complete change of current direction which may cause Huong river down stream becoming "a stagnant water area".

- Strengthening scrape off the river bed in the area from Gia Vien to Con Hen for creating a great hydrodynamic corridor and maintaining a high flow rate for scouring step by step sedimentation at the river bed area. General scrape needs to be done in short time and supplementary scrape is necessary for some years.

- Careful management of engineering works of salty prevention from tide propagating to Con Hen area which caused heavy sedimentation at river bottom of the section.

- Consolidating forest ecosystem in upstream area for regulating water availability of the catchment and flow rate in the flooding season, increasing water holding capacity in the soil and control surface erosion of the slope area.

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VỀ BỒI, XÓI ĐOẠN SÔNG HUƠNG CHẢY QUA THÀNH PHỐ HUẾ VÀ CÁC GIẢI PHÁP GIẢM THIỂU

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Huế là một thành phố du lịch và là di sản văn hoá thế giới đã được UNESCO công nhận. Sông Hương là một cảnh quan quan trọng của Huế, hiện nay đang bị suy thoái trầm trọng do tình trạng bồi xói lòng sông. Nghiên cứu bồi, xói và tìm ra các giải pháp giảm thiểu là một nhiệm vụ cấp bách nhằm bảo vệ thành phố và các cảnh quan môi trường của nó.

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