

RIVER BANK STABILITY UNDER BOAT WAVE ATTACKS: A FIELD STUDY IN CAMAU PROVINCE, THE VIETNAMESE MEKONG DELTA

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1. INTRODUCTION

Waves generated by navigating ships contain massive amounts of energy that can damage seriously the riparian and coastal environment by erosion. When extensive erosion occurs, residential areas sometimes disappear, causing large economic losses. While the causes of riverbank erosion have been the subject of numerous studies, little work has been done on the influence of boat-generated waves, even though they are episodic high energy events, and the boat wash is occurred at many locations in Mekong Delta. Coops et al.(1996) conducted an experimental study in a wave tank to study the interaction between waves, bank erosion and emergent vegetation. Field observations on ship waves in shallow water (Velegrakis et al., 2007) could provide the nearshore characteristics of wave propagation and its potential for mobilizing sediment. However, there is no quantitative data in the field site for result evaluation. Therefore, it is necessary to urgently study the relationship between boat waves and soil characteristics in the aspect of bank stability. The objectives of this study are to focus on investigating the boat-generated wave characteristics in terms of wave height, wave velocity, wave period and how waves affect on riverbank. Based on that, the assessment of bank failure and the relationship between the energy flux of boat waves and bank erosion rate would be determined.

2. MATERIALS AND METHODS

2.1. Site selections and characteristics

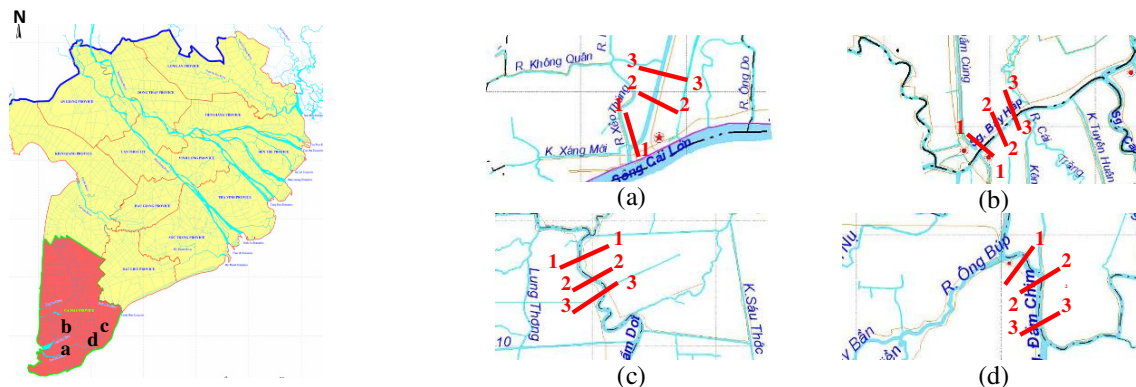


Fig.1. Study area and locations of each site (a) Cai Nai River, (b) Bay Hap River, (c) Dam Doi River, (d) Dam Chim River. At each river, the measurements were conducted at 3 transects 1-1, 2-2 and 3-3, respectively

In the Vietnamese Mekong Delta, due to specifically geographical condition, the road traffic systems are not able to be developed properly. Instead, with a dense river network, inland waterways have been built to support the demands of passages among areas. Considering as the most populated waterway in Vietnam, river traffic in Ca Mau Province is diversified in terms of type of means as engine-driven boats, canoes, high-speed boats. In recent years, the remarkable increase in both quantity and boat speeds induces waves attack on riverbank and causes bank erosion seriously. The field investigation was conducted in Ca Mau Province, the end point of the Vietnamese Mekong Delta at last February, 2013 during 1 month. Four sites were selected including Cai Nai River, Bay Hap River, Dam Doi River and Dam Chim River. At each river, the measurement was conducted at 3 transects. These locations were selected for field observation based on three conditions 1) heavy transport of boat traffic, 2) similar soil characteristics of river bank and 3) bank erosion is occurring in different level.

2.2. Methodology of measurements

The device so-called 16-T0174/A (Controls Testing Equipment Ltd.) was used to measure in-situ the shear strength of soil. Consisting of a cylindrical body containing a torsional spring and three interchangeable vanes of different size, T174 is peculiarly suitable for soft and medium cohesive soil. Particle size distribution of soil was analyzed by sieve screening method. At each transect, three hydraulic parameters including wave height, wave velocity and still water depth were measured two times per day, under high tide and low tide condition, respectively. Two boats were used for the measurement, one was berthed securely with all equipments in it while the other (5.5x2.1x0.6m) was served for wave generation. Still water depth was directly obtained by using staff gauges. Wave height observations were carried out using a video technique. A staff was placed and secured in the same position with water depth measuring point. Boat wave heights were recorded using digital camera in 30s for each case. The waves were generated by an engine-driven boat which is very popular in this region. Wave heights were controlled by boat speed, which are 30km/s and 55km/s,

Keywords: Bank erosion, boat-generated wave, energy flux of wave, shear strength of soil

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respectively. The obtained videos were split into frames for analysis. In addition, wave velocity was measured in-situ using magnetic velocity equipment (KENEK LP1100).

3. RESULTS AND DISCUSSIONS

3.1. Soil and wave characteristics

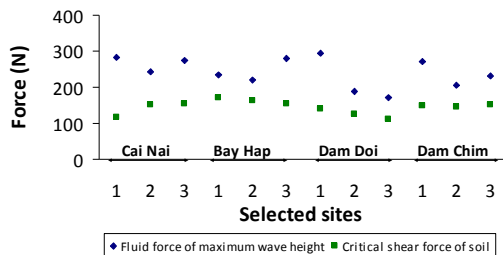


Fig.2. Comparison between fluid force of maximum wave height and critical shear force of soil

The results showed that the soil characteristics collected at 4 rivers is quite similar. Based on the particle size distribution, it can be inferred that this soil is a combination of silty clay with sand. The shear strength of soil ranges from 0.88 to 1.35 kg/cm² which is classified as medium value. Wave height varies from 13 to 25cm while the wave velocity varies from 0.179 to 0.358 m/s for an ordinary boat wave. The bank stability is being threatened since the fluid force generated by maximum wave height is greater than the critical shear force of soil. Under shallow water depth condition, wave characteristics depend on the clearance between boat hull and river bed. Wave height increases with the increase of still water depth whereas wave velocity decreases.

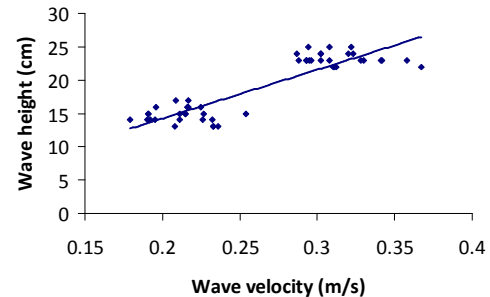


Fig.3. Characteristics of wave velocity with wave height

3.2. Bank erosion situation

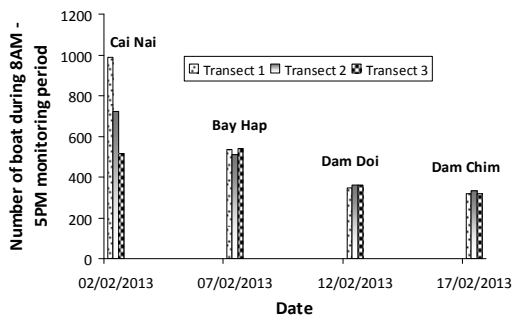


Fig.4. Boat counts at each site during monitoring period

The field observation showed the frequencies of boats in selected sites are high, especially in Cai Nai River and boat-generated waves therefore apply ceaselessly to the riverbank. As can be seen in Fig.5, bank erosion rate increases when the energy flux of boat-generated waves increases. Different from most of observed locations with bare banks, transect 3 in Cai Nai River and Bay Hap River are vegetated. The appearance of vegetation may also decrease the erosion rate. The body load of vegetation in one hand burdens river bank and makes foundation subsided, in the other hand, reinforces bank by penetrating their roots somewhat deep into the soil. This may account for these two cases at transect 3 (shown in circle in Fig.5) where the energy flux of boat-generated wave even though is considerably high, the bank erosion rate is rather small compared to other cases without vegetation.

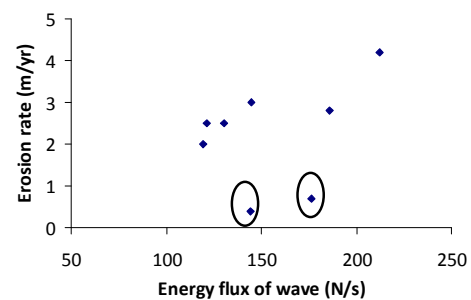


Fig.5. Relationship between energy flux of wave and bank erosion rate

4. CONCLUSION

The field investigation showed that motor boats in spite of small size, can generate substantial wave events at the experiment sites. Especially, since the boat frequency is high, riverbank gets influenced by wave-induced forces constantly that threaten bank stability. The maximum wave height can reach up to 25cm while wave velocity ranges from 0.179 to 0.358 m/s. Regarding the effect of boat waves on bank stability, boat-generated waves can apply forces on riverbank which exceed the critical shear force of soil and bank erosion therefore is occurring. With a given boat hull and speed, the energy flux of boat waves depends on the clearance between boat hull and river bed, increasing when still water depth is deeper. Bank erosion rate is not only affected by wave characteristics but also things near to water's edge. While houses (bare land at the shore) cause erosion rate happening faster, vegetation may have a tendency to reduce it.

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