**SUITABLE RIVER-BANK PROTECTION MEASURES IN BAC-LIEU AND CA-MAU PROVINCES**

**Abstract**

The interlocking channel and river in Bac-Lieu and Ca-Mau provinces with more than 5700km length has a very important position: providing fresh water, conveying seawater inland, dissolving contaminated water and waterway transport network serves the region's socio-economic development. In recent years, landslide along the riverbank in these provinces has occurred continuously, unusually and increasing seriously. River and canal bank erosion has caused damage to many infrastructure and livelihoods. Every year, authorities and people living along the river have spent alot to build a series of river adjustment, bank protection but the landslides in these provinces has not been prevented. On the other hand, many protection measures have been built with high cost but not effective as expected. To contribute to solving this pressing issue, the research result from the project "Study on solutions and technologies to prevent river bank erosion in Bac-Lieu and Ca-Mau provinces" was lead by Assoc. Prof. Tran Ba Hoang (Southern Institute of Water Resources Research) proposed four groups of measures to prevent typical landslides corresponding, often occurring in the river and canal system in Bac-Lieu and Ca-Mau provinces for many years.

**Keywords:** landslide, protection measure, river, canal, Mekong

**I. SUITABLE RIVER BANK PROTECTION MEASURE FOR TYPICAL CONDITION IN BAC-LIEU AND CA-MAU PROVINCES**

Study on natural characteristic, functional requirements of each type of river-bank protection measure in Bac-Lieu and Ca-Mau province, and also gaining knowledge through experience and advanced scientific achievements on river-bank protection technologies at similar conditions. The project proposed four groups of solutions to protect river and canal bank in Bac-Lieu and Ca-Mau provinces for some typical landslide areas

* **The first protection group**: apply for not seriously erosion areas, in which landslide bank is below 2m of height (without directly threats to infrastructure, livelihoods), due to rather small boat wave, wind wave, small tidal range, often occur along river/canal flowing into the West Sea or deeply inland river/canal flowing into the East Sea. The solutions for this kind of such areas are direct-wave reduction based on simple, low-cost, environmentally technologies. The first protection group may be:

- Planting trees such as Nypa, Rhizophora apiculata, Sonneratia at the wetland area (have water level fluctuation) and local grasses for dry upper part;

-Prevent wave's impact by plant fences combined growing common water hyacinth, water chestnut, sea grass behinds structures;

- Fixed heavy trees, broken tires, … parallel to the shore. Waves will be dissipated when transferred through these heavy things.

In case of applying plant growth solution to prevent wave's affection, it is necessary to pay attention to environmental conditions. It should be choose native plants with good wave resistance and need to regularly take care of the tree to avoid their encroachment in the river and canals, obstructing the flow and water traffic. Figure 2 shows the Rhizophora growth and plant fences solution in Cua-Lon, Nam-Can district, Ca-Mau province

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| Kết quả hình ảnh cho Cây bần, cây mắm | *Description: Picture15* |

Figure 2: River bank in Cua-Lon, Nam-Can district, Ca-Mau province was protected by Rhizophora and plant fences.

* **The second protection group**: apply for the erosion areas, in which landslide bank is above 2m of height (directly threats to infrastructure, livelihoods). This type of erosion often occurs in front of or behind tide gates, bridges, narrow section river, and large estuaries into the West Sea. The main cause of erosion is the impact of rather large waves, velocity, dynamic flow exceeding the typical erosion velocity of native material forming river bank. The proposed construction solution is long life, reasonable price measures, possibly:

- Wall embankment, one or two rows of piles with bundles of branches, bags of soil, sand inside;

-Stone mats, eco-bags (sand or slag of coal from thermal power plants inside) is tilted to create a slope ensuring stability. See the figure 3 below.

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*Figure 3: Measure protection using sand-bags*

* **The third protection group – revetment**, to protect the serious erosion areas in towns where dense population concentrated along the riverside in case there is capable of relocating free space along riverside, combining urban embellishment, creating a clean and beautiful green landscape. The main cause of erosion is due to high express-boat wave, large loads boats and riverbank are loaded by not stable constructed houses (structure of riverbanks are not broken)

The group of structural solutions is proposed as revetments; protect the surface of revetment by PS concrete mats, concrete slabs, sand-bags or mixtures of agricultural byproducts or paving stones … depends on the magnitude of velocity and waves. In order to have long-life stable structures, footprint of structures can be arranged with concrete piles, melaleuca poles, … linked together by capping beams at the elevation of 0.5m below the lowest water level. In the case of a slope river bank, the stability is not ensured, gabion are arranged below the capping beams as shown in Figure 4 below.

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Figure 4: Cross-section and revetment with concrete components.

To increase the level of stability and simplicity of construction, it is possible to replace rows of melaleuca poles and beams with a prismatic conical concrete structure or trapezoidal blockwork covered by concrete at the top, is height of 1.4m, diameter at peak is about 0.3m, diameter at bottom is 1m (block stability is needed to calculated to determine the exact dimensions for actual works). The prism is sealed at the top ensures better stability. See figure 5 below.



*Figure 5: Revetment with arranged prismatic at its footprint.*

* **The forth protection group**, to protect serious erosion, eroding holes appears close to the shore, landslides make the structure of riverbed and banks broken. The cause of this type of landslide is often due to the very large turbulent eddies creating unstable deep erosion at the confluence of rivers, in towns and cities where high building overload on the edge of riverbanks, thus disrupting structures of riverbank and riverbed. The proposed protection measures must reduce erosion and restore, increase stability of landmass has been eroded, and river banks structure have broken. The shore protection measure for these cases are currently being used in many countries and in the world as vertical walls with rows of reinforced concrete piles, floor walls connected by cap beams and anchored to the shore. Due to the weakness in mechanical properties as geological characteristics in Bac-Lieu and Ca-Mau, wall protection are constructed as concrete slabs, concretes piles creating high pressure and often does not guarantee long-term stability. We propose the solution by combining vertical wall and revetment, such as:

- Revetment with vertical wall at footprint;

- Floodwall with sloping-front structure at footprint;

***Revetment with vertical wall at footprint***

This solution is applied to landslides areas which eroded hole close to riverbank, structure of riverbank and riverbed has broken (due to high building, heavy object loaded on the edge of river bank). The cross-section and the characteristics shape of this kind of combination are shown in figure 6.

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Figure 6: The cross-section of revetment with vertical wall at footprint, vertical wall section is composed by row of piles with capping beams.

Another example of this type structure, the vertical wall at footprint is replaced by prismatic conical concrete structure or trapezoidal blockwork covered by concrete at the top as shown in figure 7.



Figure 7: The cross-section of revetment with trapezoidal blockwork at footprint

* ***Floodwall with sloping-front structure at footprint;***

When erosion occurs in residential areas, cities and towns and there is not deep eroded hole close to the shore, and it is necessary to protect and expand riverside land, the proposed solution is floodwall with sloping-front structure at footprint shown in figure 8 below.



Figure 8: Revetment combined with floodwall

Figre 9 as below is a cross-section of revetment combined with vertical wall. Row of piles linked by capping beams is used to keep stability of revetment.

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Figure *9: The cross-section of revetment combined with vertical wall, keeping stability by row of linked capping beams pile.*



*Figure 10: The cross-section of revetment combined with vertical wall, keeping stability by prismatic conical concrete structure*

**II. CONCLUSION AND RECOMENDATIONS**

On the basis of synthesizing, analyzing and evaluating advantages and disadvantages protection structures in the world and in Vietnam which have similar natural conditions as Bac-Lieu and Ca-Mau province, our project proposed four type groups of riverbank protection measures suitable for typical eroded areas often occurring in both of provinces over the past decades. Due to landslides taking place in many areas, the funding for handing landslides is huge. We propose that authorities at all levels should apply non-structural measures such as relocation and wide-spread propaganda to each person and family living along the river. Simple measures should be applied (the first group) widely thanks to simple technologies and low-cost.

***Source: Final research report “Study on technological solutions to prevent river bank erosion in Bac-Lieu and Ca-Mau provinces”, Southern Institute of Water Resources Research, Tran Ba Hoang, 2018.***