

ASSESS THE APPLICABILITY OF ANTI-OVERTOPPING BARRIER FOR RIVER DYKE BY FOAM-CORE COMPOSITE PANEL (VTC.FC.3020) IN VIET NAM

Nguyen Chi Thanh¹, Vu Le Minh¹, Tran Thi Nga¹,
Luyen Le Dieu Linh¹, Vu Van Xiem¹
*1. Hydraulic Construction Institute
Vietnam Academy for Water Resources*

Abstract: *Mobile overtopping prevention technology for rivers due to floods has been applied in many countries around the world. However, it is not yet popular in developing countries like Vietnam due to the high cost and we have not yet mastered this technology. This paper introduces a new technology by using barriers with composite-coated foam panels. The structure has been completely fabricated, tested with real-life flood scenarios and deployed in the field. The results show that the structure completely meets the technical requirements and has many outstanding advantages. compared to traditional solutions (using sandbags or reinforced concrete panels).*

Keywords: *Overtopping; Anti-overtopping; River dyke; Foam-core; Composite*

1. INTRODUCTION

The intense exploitation of energy and natural resources, besides bringing better life to people, also leads to rapid changes in climate and weather in a negative direction. A typical result of the impact of climate change is that floods occur more frequently and in places where they did not exist [1]. High-risk areas are protected by solid constructions such as dikes and walls. Problems arise in densely populated areas where there is no space for dykes and retaining walls because it will cut off traffic routes and obstruct observation axes; or at locations where dikes and retaining walls are lacking in elevation (due to unreasonable design, or subsidence during use) [2]. In these cases, mobile structures are considered as a suitable solution with the following advantages: preventing overflow due to flood while still ensuring traffic; fast deployment time; and temporarily raise the water barrier height of the permanent flood control structures when required, especially under unusually extreme conditions [3].

Viet Nam has a large river system, the terrain is mostly mountainous, so when there is heavy rain, the water from this area often rushes down quickly, raising the water level of both large and small rivers. Every year we have to face floods all over the country. Even though floods have caused a lot of damage to people and properties, the basic and almost only solution is using sandbags to compensate for the elevation of the dike surface or to build a permanent retaining wall with reinforced concrete to prevent overflow. This fact shows that we are far behind the world in the field of technical solutions to prevent temporary overflow for river dykes.

According to the research results of the scientific research project at the Ministry of Agriculture and Rural Development "Research on application and development of anti overtopping for river dykes caused by floods" [4], in some Northern provinces, there are approximately 400km in total. Dyke sections are lacking in elevation and need to be compensated during the rainy season. That shows the huge demand for anti-overtopping barrier application.

This paper introduces a research on anti-

Receipt Date: October 28th, 2022

Review Approval Date: November 08th, 2022

Publish Approval Date: November 30th, 2022

overtopping barrier for river dike by foam-core composite panel – VTC.FC.3020 (in which, VTC is a short abbreviation for Hydraulic Structure Institute; “FC”: Foam-core Composite material; “3020”: 30cmx20cm(HxB) – dimension of a panel).

This is a mobile structure that can be easily transported and disassembled due to its light weight; components are fully bolted together so can install entire manually or by light motor vehicles; Quick and effective deployment especially when there is an urgent requirement. The material for making the sheet is composite foam, which is a material that has many advantages: lightweight, resistant to Vietnam's weather and climate conditions, anti-corrosion, and can be manufactured domestically to help reduce costs significantly compared to materials (suitable for portable spill-proof solutions) that need to be imported from abroad.

This structure can prevent overflows through dykes and embankments into residential areas, industrial parks, hospitals, etc., such structures have high barrier height. The water can be raised without expanding the ground. Thanks to lightweight materials, the solution can reduce labor and machine costs.



Figure 1: Overtopping barrier on dyke crest by VTC.FC.3020

2. STRUCTURE AND PRINCIPLE OF OPERATION

The anti-overtopping barrier made of foam-core composite material consists of the following main components (Figure2). The

panel is rectangular box shape, made of foam material and covered by composite outside. The support pillar which is made from I-shaped stainless steel used to fix the two ends of the panel. The size of the ear part of the support pillar is designed to fit the thickness of the pad and the watertight seal. Stainless steel bottom plate is pre-installed in the concrete base. There are four holes waiting for bolts to fix the support pillar and support legs, and the bottom plate is welded with four L-shaped steel bars to increase adhesion to the substrate. In order to enhance stability of the support pillar, two struts connect the support pillar through the steel ear and the horizontal fixing bar. The panels can fix vertically and horizontally thanks to an upper U-shaped wedge cluster and a set of horizontal wedges, respectively. Watertight rubber gaskets that help to prevent water from leaking are installed between the panel and the ground, between panels themselves and between the panel and the support pillar. The gasket is attached on the the support pillar by bolts.

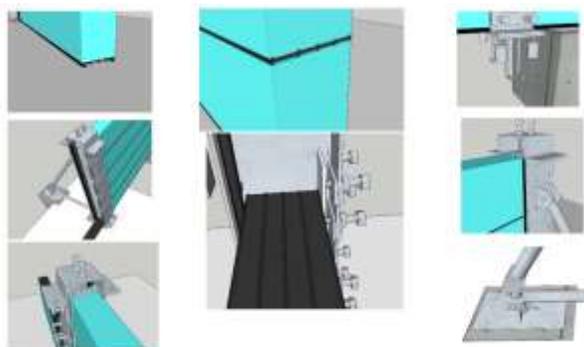


Figure 2: Details of components of an anti-overtopping barrier

3. PHYSICAL MODELING AND FIELD TESTING

3.1. Lab experiment

There are three scenarios that were implemented into consideration as following:

Scenario 1: The water column increases gradually from the base level to $H_{max} = 150\text{cm}$ and stays fixed (the water column increases step by step $H = 30\text{cm}, 60\text{cm}, 90\text{cm}, 120\text{cm}$

and 150cm). At each level of water column, hold until the displacement and deformation of the plate have reached a stable level and then continue to increase the water column to the next level.

Scenario 2: The water gradually recedes from H_{max} to the base level (decreases step by step, same principle as Scenario 1).

Scenario 3: The water level rises rapidly to the

water column H_{max} and rapidly recedes to the elevation of the datum.

There are eight displacement and eight strain measurement points (as showed in Figure4) that are measured automatically by electrical measuring heads and sensors. Those data are then analyzed by the Multi Recorder TMR-211 (Figure3) with reading frequency of twenty data per second.



Figure 3: Experimnt process

1- Manufacturing; 2- Install the main support pillar; 3- Install the plate (by one man); 4 – Install measuring devices; 5 – Calibrate and record data



Figure 4: Position to install measuring devices



Figure 5: The VTC.FC.3020 system is well-functioning when water head is 1,7m

3.2. Field testing

Structural durability has been demonstrated through indoor experiments with simulated

flood level scenarios. To evaluate the operational flexibility of the VTC.FC.3020 system, we conducted a trial demonstration installation at a border gate on the Ngoc Tao dyke, located in Tam Thuan Commune, Phuc Tho District, Ha Noi (Coordinates 21,086473; 105,634208, Km13+000).



Figure 6: Operation of the VTC.FC.3020 system on the border gate during the flood

The border gate is 8.0m wide; there are pre-installed concrete slabs (20x20x400cm) that were already prepared in case of flood. The application of VTC.FC.3020 system can completely replace traditional concrete slabs.



Figure 7: Application of VTC.FC.3020 in Ngoc Tao dyke, Ha Noi (11.2022)

4. RESULTS AND DISCUSSION

The experimental process shows that the anti-overtopping barrier with composite foam-coated panels operates stably and satisfies the technical requirements as designed. In the condition that the pillars are pre-assembled, with 01 worker, it takes 15 minute to assemble 12 panels of $20 \times 30 \times 200 \text{ cm}$ with watertight seals and auxiliary bolt system. The maximum displacement of struts in the scenarios where the water rises and falls steadily (Scenario 1, 2) is $0,25 \text{ mm}$ and almost does not move in the scenario where the water rises and falls rapidly (Scenario 3). Meanwhile, the displacement of the top of the support pillar is $0,6 \text{ mm}$. The structure function normally as the water level reaches $1,7 \text{ m}$ (20cm higher than the designed H_{max}), as illustrated in Figure 5.

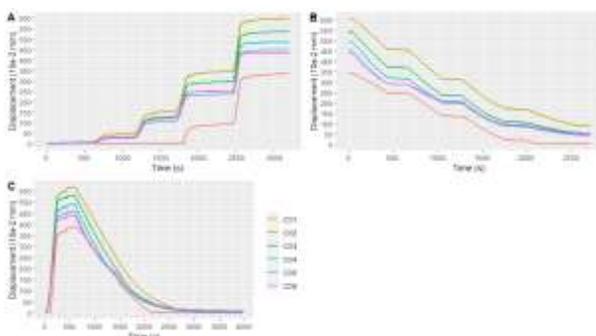


Figure 8: Displacement of foam-core composite panel

A – Scenario 1; B – Scenario 2;
C – Scenario 3

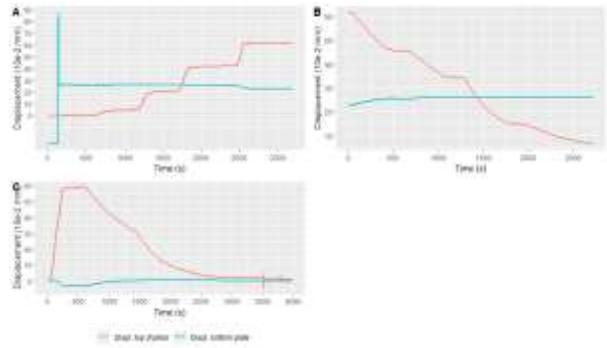


Figure 9: Displacement of top of support pillar and bottom plate

A – Scenario 1; B – Scenario 2;
C – Scenario 3

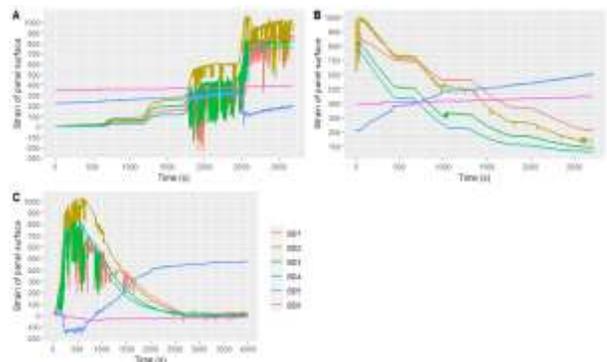


Figure 10: Strain of foam-core composite panel surface

A – Scenario 1; B – Scenario 2;
C – Scenario 3

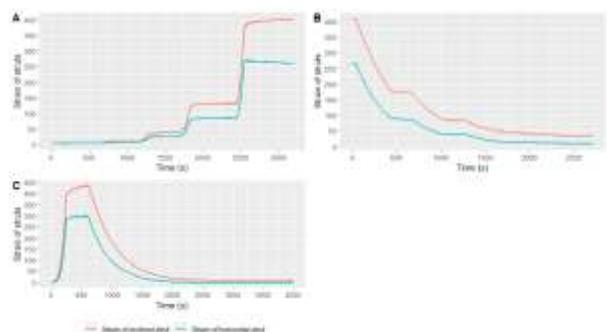


Figure 11: Strain of struts

A – Scenario 1; B – Scenario 2;
C – Scenario 3

The physical model and field testing has proved that the VTC.FC.3020 system completely meet the technical requirements and can be applied in practice.

The installation time is very fast: 02 people can complete manually the installation of the system according to the design in 22 minutes (12 panels, LxBxD = 200x30x20cm divided into two compartments, 1 steel support pillar, struts, bottom plates and rubber gasket).

In case the water height $H=1,7m$ (designed H_{max} is 1,5m), the structure is still operating stably (as can be seen in Figure 5), the maximum displacement of the plate is only 6,0mm, displacement of the support pillar's top is 0,6mm. When the water height H is less than 1,0m, thinner panel can be used ($D =$

$10\div 15cm$) or reduce the number of composite layers depending on actual conditions.

Composted porous materials can perfectly be used to fabricate panels for water blocking purposes with a larger water column. However, it is important to pay attention to the issue of water tightness

In order to evaluate the economic efficiency of the solution, the right wall structure VTC.FC.3020 is compared with two traditional solutions: using sandbags and using concrete panels with the same unit of $1m^2$ to block water. The results are as shown in the Table 1.

Table 1: Compare cost of three solution to prevent dyke overtopping

Solution	Material	Unit to compare	Cost (VNĐ)	Time to install	Method	Ghi chú
Sandbags	Polypropylene	$1m^2$ block of water	1.800.000	20 mins/ 12 p.p	manual	40 sacks of type 40x20x60cm/bag; 06 people shoveling sand + tying bags; 06 people line up to transport sacks from the material gathering place to the dike surface with a distance of 100m
VTC.FC.3020	Foam-core composite	$1m^2$ block of water	5.800.000	10mins/ 2 p.p	manual	04 panels of 30x20x200cm/panel; 01 person can carry 01 panel and arrange it in order from bottom to top, the distance from the gathering place to the installation location is 10m.
Concrete panels	Reinforced concrete	$1m^2$ block of water	4.600.000	15 mins/ 3 p.p + 01 crane machine	manual combined mechanized	05 concrete planes of 20x20x400cm

						type/plane; use a crane to transport the panel to the correct position; 02 people carry the support pillar with a distance of 10m
--	--	--	--	--	--	---

From Table, we can see that the solution of using composite foam wall is more expensive than traditional solutions. However, this solution has the absolute advantage of installation time in emergency conditions. The lifespan of composite materials is high (20-30 years) so they can be reused many times, while using pineapple sacks can only be used for 1-2 flood seasons.

5. CONCLUSIONS

Anti-overtopping barrier for river dike by foam-core composite panel – VTC.FC.3020 has proved its effectiveness through physical model test and field test. The panels are stacked on top of each other, fixed by a system of supports and bolts. Rubber gaskets are placed at the junction between the panels, between the panels and other parts for watertightness. The upper part is arranged with bolts at both ends of the slot to keep the system fixed against the impact of water flow.

Light weight structure; panels are transported by rudimentary vehicles or small motor

vehicles; the construction is installed completely manually; so it can be deployed quickly and very efficiently when there is an urgent requirement. Material for making the panel is composite foam that has many advantages: lightweight, durable to Vietnam's weather and climate conditions, anti-corrosion, and can be manufactured domestically to help reduce costs. significantly compared to materials that need to be imported from abroad. The water barrier height can be raised without expanding the ground.

Acknowledgement:

This paper has used the results of the scientific research project at the Ministry of Agriculture and Rural Development (MARD): " Research on application and development of anti-overtopping for river dykes caused by floods ". We would like to thank MARD for creating conditions for the Institute of Water Resources and the Research Team to carry out this study.

REFERENCE

[1] UNEP, "How climate change is making record-breaking floods the new normal," 2020. [Online]. Available: <https://www.unep.org/news-and-stories/story/how-climate-change-making-record-breaking-floods-new-normal#:~:text=Climate change and floods—how climate change increase flood risk>.

[2] B. Koppe and B. Brinkmann, "Opportunities and Drawbacks of Mobile Flood Protection Systems," *Coast. Eng. Proc.*, vol. 1, no. 32, p. 24, 2011, doi: 10.9753/icce.v32.management.24.

[3] B. Koppe and B. Brinkmann, "Development and testing of water-filled tube systems for flood protection measures," in *Structural Membranes 2011 - 5th International Conference on Textile Composites and Inflatable Structures*, 2011, pp. 319–329.

- [4] Nguyễn Chí Thanh, “Nghiên cứu ứng dụng, phát triển kết cấu chống tràn cho đê sông do lũ,” *Đề tài NCKH cấp Bộ NN&PTNT*, 2022.