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Comprehensive Study on Effectiveness of Automatic Flood Door Barrier

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Abstract

Flood barriers, encompassing structures such as walls, levees,dams, or gates, play a vital role in safeguarding against the detrimental impact of escalating water levels. These barriers, made of materials such as concrete or steel, are crucial for protecting residential, commercial, and critical infrastructure sectors. Their efficacy depends on variables such as the flood event's configuration, location, and scale. The objective of this project is to create a practical and user-friendly prototype of an automatic flood door barrier, mostly constructed from acrylic. Additionally, the project aims to assess the effectiveness of the automatic flood door barrier in with standing floods in residential areas. The project's to ascertain the optimal application of acrylic in the fabrication of an automatic flood door barrier, with the ultimate aim of alleviating theUltimately, the properties of acrylic render it a desirable substance for inhibiting the ingress or seepage of water into the dwelling. Further studies should focus on investigating the material effects of flood door barriers to fully comprehend the benefits and potential of acrylic, which distinguishes itself from other materials.

1. Introduction

Floods are a frequent and devastating natural disaster, particularly affecting countries such as Malaysia, where substantial and often torrential rainfall during monsoon seasons significantly heightens the risk of flooding [1]. The repercussions of these floods are extensive, impacting infrastructure, homes, and the livelihoods of residents. Despite the implementation of conventional flood prevention methods like comprehensive drainage systems and extensive reforestation initiatives, these measures sometimes fall short in effectively mitigating the immense destruction caused by flooding [2]. Traditional methods can be overwhelmed by the sheer volume of water during heavy rains, leading to significant damage and displacement of communities [3][4]. To address these challenges, this study introduces an innovative approach to flood prevention through the development of a prototype flood door barrier [5][6]. Designed to be automated and primarily constructed from acrylic material, this barrier aims to explore the most efficient use of acrylic in constructing these barriers, create a user-friendly and highly functional model, and rigorously assess its performance through testing. Acrylic is chosen for its durability, transparency, and resistance to water, making it an ideal material for flood barriers.

The proposed flood door barrier aims to significantly enhance the protection of residential homes against floodwaters, boasting a rapid deployment process that requires no more than 5 to 7 minutes to fully activate. This quick and efficient deployment is crucial in emergency situations where every minute counts. The barrier can be easily deployed by homeowners or automatically triggered by the integrated sensor system, ensuring protection even in the absence of occupants. Furthermore, the flood protection system is integrated with advanced sensor switches and alarm sensors, providing automatic activation and real-time warnings to homeowners. These sensors ensure that the barrier can be deployed promptly.

2. Materials and Method

2.1 Materials

This section provides a detailed explanation of the project and the materials chosen for its effective implementation. The flood barrier is constructed from several key materials as shown in Fig 1: an acrylic barrier that acts as the primary flood shield, sealing rubber that prevents water entry into the house, and polystyrene to make sure shield the acrylic. The barrier also includes alarm sensors to detect rising water levels and sensor switches for early warning and automatic activation of the semi-automatic flood barrier. Additionally, the triwater concept is applied to the flood barrier wall for enhanced protection.

(a) **(b)** **c)**

Fig. 1 *(a) Polystyrene, (b) Acrylic Board, (c) Prototype of flood door barrier*

The application and testing of this flood barrier are also discussed. The barrier's functionality was tested to ensure it effectively prevents water ingress. The project cost and how it differs from existing flood barriers are also covered, highlighting its potential for cost savings and improved efficiency in flood protection.

2.2 Arcylic Testing

Testing is a crucial step in evaluating a system or component to identify discrepancies between expected and actual results, ensuring that it meets design specifications and functions as intended. For this project, testing the acrylic material is vital, as it is the primary component of the flood barrier. The barrier's effectiveness in preventing water entry depends on the acrylic's performance. To assess its suitability, an experiment is conducted in the Fluid Mechanics Laboratory, UTHM Campus Pagoh to measure the force exerted on a sluice gate. This test simulates real-world flood conditions to evaluate how the acrylic responds to dynamic forces, identifying potential weaknesses or failure points. The results from these tests are essential in determining whether the acrylic can withstand the pressures it will face, thus playing a pivotal role in ensuring the flood barrier's successful formation and functionality. Fig.2 shows the acrylic test in sluice gate.

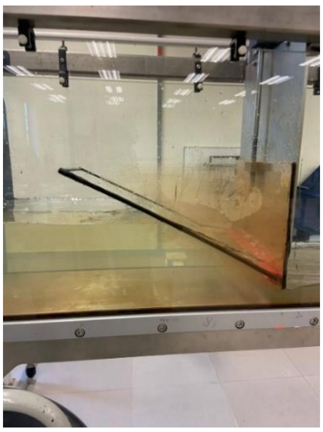

Fig. 2 *Acrylic test In Sluice Gate*

3. Results and Discussions

3.1 Strength of Arcylic

Table 2 represents the testing result of the primary material which is Acrylic. Fig. 3 shows that as the height of water increases, the time required for it to reach the acrylic significantly decreases. Initially, the time drops from 104.81 seconds at 50 cm to 46.81 seconds at 100 cm, and continues to decline slightly to around 46-49 seconds for heights up to 250 cm. Beyond 250 cm, there is a sharp decrease, with the time dropping to 14.28 seconds at 255 cm and further to 11.45 seconds at 260 cm. This suggests that the addition of acrylic greatly accelerates water flow at higher heights, indicating a non-linear relationship due to changes in flow dynamics at larger volumes.

Table 2 *Result Testing of the primary material which is Acrylic*

Time	Flow RateQ (M^3/s)	Height ofwater before acrylic (cm)	Height of water after acrylic (cm)	Deflection (cm)	Condition (Crack / Not Crack)
104.81	11.88	50	0	0	Not Crack
46.81	12.7998	100	0	0	Not Crack
46.14	14.7701	150	0	0	Not Crack
49.91	17.1791	200	5	0	Not Crack
49.54	22.9897	250	10	0	Not Crack
14.28	29.9322	255	25	0	Not Crack
11.45	42.0410	260	35	0	Crack

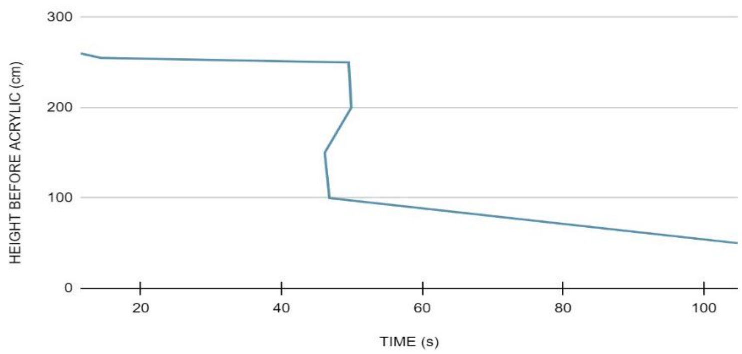

Fig. 3 Height before Acrylic vs Time

Fig. 4(a) shows that as the flow rate increases, the time decreases significantly. Initially, at a flow rate of 11.88 m^3/s, the time is 104.81 seconds, which drops to 46.81 seconds at 12.80 m^3/s and continues to decrease slightly for flow rates up to 22.99 m^3/s. Beyond this, there is a sharp reduction, with the time plunging to 14.28 seconds at 29.93 m^3/s and further to 11.45 seconds at 42.04 m^3/s. This suggests that higher flow rates greatly speed up the process, indicating a non-linear relationship due to changes in flow dynamics at larger volumes. According to Fig 4(b), the acrylic barrier shows no bending (zero deflection) regardless of water height. This suggests the acrylic's exceptional strength in withstanding water pressure. Since it maintains no deflection at all water levels, this acrylic is likely ideal for barriers requiring high precision and accuracy. After all, deflection totally plays a crucial part since tiny deflections in delicate equipment can lead to major errors.

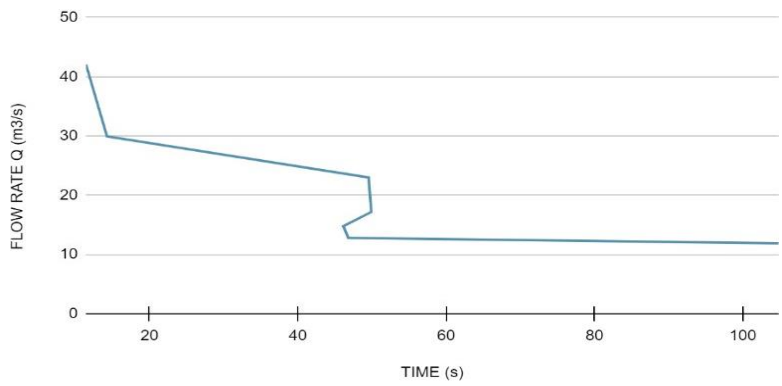

Fig. 4(a) *Flow Rate Vs Time*

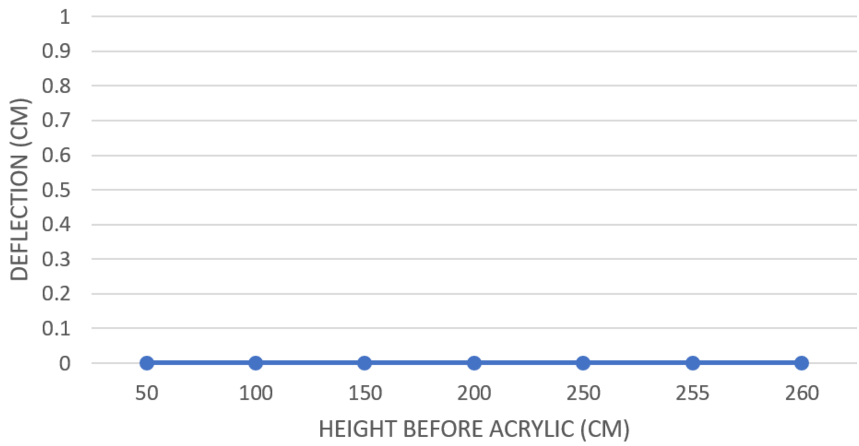

Fig. 4 (b) *Deflection vs Height before Acrylic*

4. Conclusion

In general, flood barriers are essential for reducing the detrimental impacts of flooding, which have the capacity to severely damage people, property, and infrastructure. Consequently, inundation barriers provide a practical solution. Shield vulnerable regions from the destructive effects of rising water. Furthermore, flood barriers are typically built from high-quality materials that can withstand the immense pressure exerted by inundation.

In this study, acrylic has been selected as the principal material to be used in the flood door barrier. The main constituent of flood door barriers is commonly acrylic. The material is transparent, strong, and inflexible. It exhibits glass-like characteristics such as clarity, brightness, and transparency, while being half as heavy and far more resistant to impact than glass. The acrylic- based automatic flood door barrier is currently undergoing experimental testing as a direct consequence of utilising this material.The findings were encouraging, particularly when the water levels were low and the flow rates were moderate, as the leakage was successfully controlled. The Flood Door Barrier prototype has demonstrated its efficacy as a robust defensive measure since the deflection is 0cm when conducted testing for certain size that has been selected.This is particularly accurate in regions susceptible to regular flooding or in close proximity to water bodies, such as river.Based on the available testing results. Moreover, this device has the capacity to serve as a crucial instrument in safeguarding susceptible regions from catastrophic flood events. Their execution not only averted harm to infrastructure and property, but also guaranteed the safety and security of citizens' well-being.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Muhammad Muzammil Mohd Khairi, Nor Asikin Yusfandi,;* ***data collection:*** *Muhammad Ali Izuan Dzulkeflee;* ***analysis and interpretation of results:*** *Muhammad Muzammil Mohd Khairi, Nor Asikin Yusfandi, Muhammad Ali Izuan Dzulkeflee;* ***draft manuscript preparation:*** *Muhammad Ali Izuan Dzulkeflee, Khairi Bin Supar. All authors reviewed the results and approved the final version of the manuscript.*

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