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The Development of Semi-Auto Flood Door Barrier

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Abstract

Flood barriers play a crucial role in mitigating the devastating impact of flooding events. This project focuses on testing flood barriers to enhance their effectiveness and reliability in reducing the adverse effects of floods. The recent floods in Malaysia have resulted in significant infrastructure destruction, underscoring the urgent need for flood mitigation strategies to minimize fatalities and property damage. Flood control techniques aim to confine water and prevent it from inundating buildings, particularly those situated in flood-prone areas. To ensure the optimal performance of new flood barriers, multiple standardized tests must be conducted during their development. This study specifically investigates the feasibility and effectiveness of temporary flood barriers (TFBs) in reducing the severe consequences of floods. By exploring the potential of TFBs and assessing their suitability as a flood mitigation strategy, this research aims to contribute to the development of effective flood control measures. TFBs are physical structures erected at the entrances of buildings to safeguard their infrastructure from water damage during flood events. They serve to minimize property damage and are particularly beneficial in flood-prone areas. The study encompasses a comprehensive discussion of successful TFB applications, along with an overview of the various types of TFBs available on the market, including their associated advantages and limitations. By examining and evaluating TFBs, this research seeks to provide valuable insights that can inform the development of effective flood control measures in Malaysia.

1. Introduction

Floods are natural calamities that result in extensive devastation and pose significant risks to lives, infrastructure, and the environment [1]. They can be triggered by heavy precipitation, snowmelt, tropical storms, or the failure of dams and levees. Floods occur suddenly and with limited warning, making them highly destructive and challenging to manage effectively. The frequency and severity of floods are exacerbated by climate change, amplifying the vulnerability of communities [2]. Flood barriers, also known as flood defense systems, are engineered structures designed to prevent or reduce the ingress of floodwaters [3]. They can be permanent installations or deployable systems activated during flood events to provide protection. Case studies, such as the Netherlands, demonstrate the effectiveness of flood barriers in mitigating flood risk [4].

Organizations like the American Red Cross and governmental agencies like the Federal Emergency Management Agency (FEMA) offer resources and guidelines on flood safety measures and flood-proofing techniques. These resources contribute to enhancing resilience and response to flood events. Additionally, the implementation of flood barriers and the adoption of safety measures can lead to cost savings in the long term. While the initial investment in constructing flood barriers may be substantial, the potential damage and losses prevented by these structures can far outweigh the costs. By protecting valuable assets, homes, and infrastructure, flood barriers can save communities and governments from the financial burden of post-flood recovery and reconstruction efforts [5].

Furthermore, flood barriers can contribute to sustainable urban planning and development. By delineating flood-prone areas and establishing protective measures, flood barriers enable communities to make informed decisions about land use, infrastructure development, and building codes. This proactive approach helps prevent further encroachment into high-risk zones and promotes the creation of more resilient and sustainable communities.

Lastly, the presence of flood barriers can have positive impacts on insurance availability and affordability. Insurance companies often consider the level of flood risk when determining coverage options and premiums. By implementing flood barriers and reducing flood vulnerability, communities may be eligible for lower insurance rates, making coverage more accessible and affordable for residents and businesses. In conclusion, floods pose significant threats, and their occurrence and severity are exacerbated by climate change. The implementation of flood barriers and the adoption of safety measures play a crucial role in mitigating flood risks and enhancing resilience in vulnerable areas.

2. Materials and Methods

2.1 Preparation Materials

The selection of materials for each component of the structure has been thoughtfully considered. Visual representations in the corresponding figures provide further clarity and aid in visualizing the chosen materials. Fig. 1(a) visually represents the polystyrene box, emphasizing its durability and buoyancy, crucial attributes for an effective flood barrier. Fig. 1(b) highlights the sealing rubber material, underscoring its essential role in ensuring proper sealing and preventing water leakage. Robustness and water resistance are visually showcased in Fig. 1(c), depicting the nylon PVC tarpaulin vinylon, chosen to enhance the barrier's integrity. The inclusion of Fig. 1(d) illustrates the spring mechanism, visually representing its contribution to the barrier's flexibility and adaptability in accommodating varying water levels. Lastly, Fig. 1(e) presents the wire cover, visually conveying its significance in protecting the internal mechanisms of the barrier, ensuring long-term functionality and durability. These visual representations complement the detailed descriptions in Table 1, solidifying the meticulous approach taken in selecting materials, ultimately resulting in a flood barrier designed to effectively combat the impacts of flooding.

Firstly, there is a polystyrene box, which has been proven effective in maintaining the temperature of its contents based on recent research [6]. These boxes play a crucial role in preserving the integrity and quality of perishable items during transportation. Fig. 1(a) depicts the appearance of the polystyrene box. The prototype also includes a sealing rubber, commonly used in various industrial applications such as automotive, aerospace, manufacturing, and more. Its purpose is to ensure a reliable seal in engines, pipelines, hydraulic systems, doors, windows, and other similar applications [7]. Fig. 1(b) illustrates the sealing rubber. Another material used in the prototype is nylon PVC tarpaulin vinylon. This material is highly durable and exhibits exceptional resistance to water, chemicals, and UV radiation, making it widely utilized across diverse industries [8]. Fig. 1(c) represents the nylon PVC tarpaulin vinylon.

The prototype incorporates two springs, which possess the unique characteristic of elasticity. Springs can deform when subjected to a load and then restore themselves to their original shape [9]. These components play a vital role in various applications where elasticity and flexibility are required. Fig. 1(d) shows the appearance of the springs. Lastly, the prototype includes a wire cover, which is designed to protect wires and reduce tripping hazards by organizing and keeping them out of the way. This component helps prevent damage to the wires and ensures a safer environment. Fig. 1(e) displays the wire cover. These materials, including polystyrene boxes, sealing rubber, vinyl tarpaulin PVC nylon, springs, and wire covers, are important components of the prototype and serve a specific purpose in each.

(a) (b) (c) (d) (e)

Fig. 1 *(a) First picture; (a) Polystyrene box; (b) sealing rubber; (c) nylon PVC tarpaulin vinylon; (d) spring; and (e) wire cover*

2.2 Cost of Total Flood Barrier

Table 1 unveils the intricacies of pricing when it comes to acquiring a cutting-edge semi-automatic flood barrier, shedding light on the financial considerations involved. Meanwhile, Table 2 offers a comprehensive analysis of the overall cost of the barrier, providing valuable insights into the various expenses encompassing its acquisition and installation. Based on Table 2, the total cost for the flood barrier is Rm 71.55.

Table 1 *Specific cost of semi–auto flood barrier prototype*

Types of materials	Price/unit (RM)	Quantity	Price (RM)
Polystyrene	20.00	1	20.00
Canvas	27.95	1	27.95
Reservior	18.50	1	18.50
Rubber Seal	18.90	1	18.90
Wire Cover	8.00	1	8.00
Spring	2.50	2	5.00
Simen	2.40	1	2.40
Silicone	3.90	3	11.70

Table 2 *Barrier Cost*

Types of materials	Price/unit (RM)	Quantity	Price (RM)
Canvas	27.95	1	27.95
Rubber Seal	18.90	1	18.90
Wire Cover	8.00	1	8.00
Spring	2.50	2	5.00
Silicone	3.90	3	11.70

2.3 Flood Barrier Process

The diagram presented in Fig. 2 outlines the sequential workflow of the Semi-Automatic Flood Barrier, encompassing crucial activities including design, production, simulation comparison, and rigorous testing. This meticulous process ensures the development of a resilient and efficient flood barrier system.

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Fig. 2 *Semi–Automatics Flood Barrier Process*

2.4 Application Flood Barrier in Building

The installation of flood barriers in buildings is a crucial and effective measure to mitigate the devastating effects of floods. These barriers are specifically designed to create a physical barrier between the building and rising floodwaters, aiming to prevent water ingress and minimize damage to the structure and its contents. Flood barriers can be integrated into the building's design from the initial stages of construction, such as incorporating deployable walls, flood-resistant doors, and windows, or they can be retrofitted onto existing structures to enhance their flood resilience. The materials used in flood barriers are carefully selected for their durability and ability to withstand the force of floodwaters, often made of robust materials like reinforced concrete, steel, or composite materials. They are equipped with mechanisms that allow for quick and efficient sealing of openings, creating a watertight seal to prevent water from entering the building.

By incorporating flood barriers into buildings, property owners can significantly reduce the risk of flood damage, protect valuable assets, and enhance the overall resilience of their structures in the face of increasing flood events. These barriers not only provide a physical barrier against floodwaters but also serve as a proactive defense strategy, allowing occupants to have more time to evacuate or implement emergency measures. Furthermore, flood barriers can help lower insurance costs for the property, increase the market value, and provide a sense of security to occupants. As the frequency and severity of floods continue to rise due to climate change and urbanization, the implementation of flood barriers in buildings becomes an essential component of comprehensive flood risk management strategies, promoting sustainable and resilient urban development.

3. Results and Discussion

The 3-dimensional design of this innovative product was meticulously crafted using Solid Work 2019 software, ensuring precision and accuracy. Fig. 3(a) provides a comprehensive illustration of the prototype, showcasing its dimensions, including the door, while Fig. 3(b) highlights the U-structure, which enhances stability and durability. Furthermore, Fig. 3(c) showcases the dimensions of the canvas used as a barrier wall, which acts as a formidable defense against flooding. These meticulous design details and measurements collectively contribute to the prototype's robustness and effectiveness in mitigating the impacts of floods.

The polystyrene box used in the prototype has dimensions of 40 cm (length) x 58 cm (breadth) x 3.06 cm (thickness). It is made of foam polystyrene, which is a lightweight and durable material. These boxes play a crucial role in the prototype as the main structural support for the flood barrier, providing stability and buoyancy. The prototype also includes a separate door that measures 18.3 cm in size. The door is made of a material that is suitable for flexibility and water resistance. It allows for easy opening and closing, providing convenient access to the secure area protected by the barrier. The dimensions of the prototype are depicted in Fig. 3(a).

The U-structure you described consists of parts that form a U-shape with dimensions of 25 cm in width and height. The supports, which are spaced apart by 19 cm (center-to-center), are made of a strong and long-lasting material, specifically a wire cover. The purpose of this U-section is to serve as a support for a flood barrier. It is positioned in front of the entrance, likely to provide protection against flooding and prevent water from entering the area behind it. The installation process would involve securing the U-shaped structure firmly in place, ensuring that it can effectively withstand the force of the floodwater. This setup is designed to provide a barrier against potential flooding and protect the area in which it is installed. Fig. 3(b) detailing dimensions of U-Structure.

The barrier material chosen for the prototype flood barrier is Nylon PVC Tarpaulin Vinylon. This material provides several advantageous properties such as water resistance, strength, and durability, making it suitable for shielding the main structural components of the flood barrier. Fig. 3(c) shows the dimensions of the canvas.

To install the barrier material, the steps should be first to cut the Nylon PVC Tarpaulin Vinylon sheets to the appropriate size, measuring 15 cm in width and 22.4 cm in height. Ensuring accurate dimensions will facilitate a proper fit for the barrier material. Next, connect the cut sheets of Nylon PVC Tarpaulin Vinylon to the U-section prototype in front of the door. This involves positioning the sheets in the designated area to cover and protect the entrance. After that, employ suitable attachment techniques, such as adhesive bonding or mechanical fasteners, to securely bind the barrier material to the core structure of the U-section prototype. This step ensures that the material remains in place during potential flooding scenarios. Lastly, it is crucial to ensure that the barrier material is firmly and securely fastened to the prototype structure. This precautionary measure minimizes the risk of water seepage or breaches in the barrier, enhancing its effectiveness in preventing water intrusion.

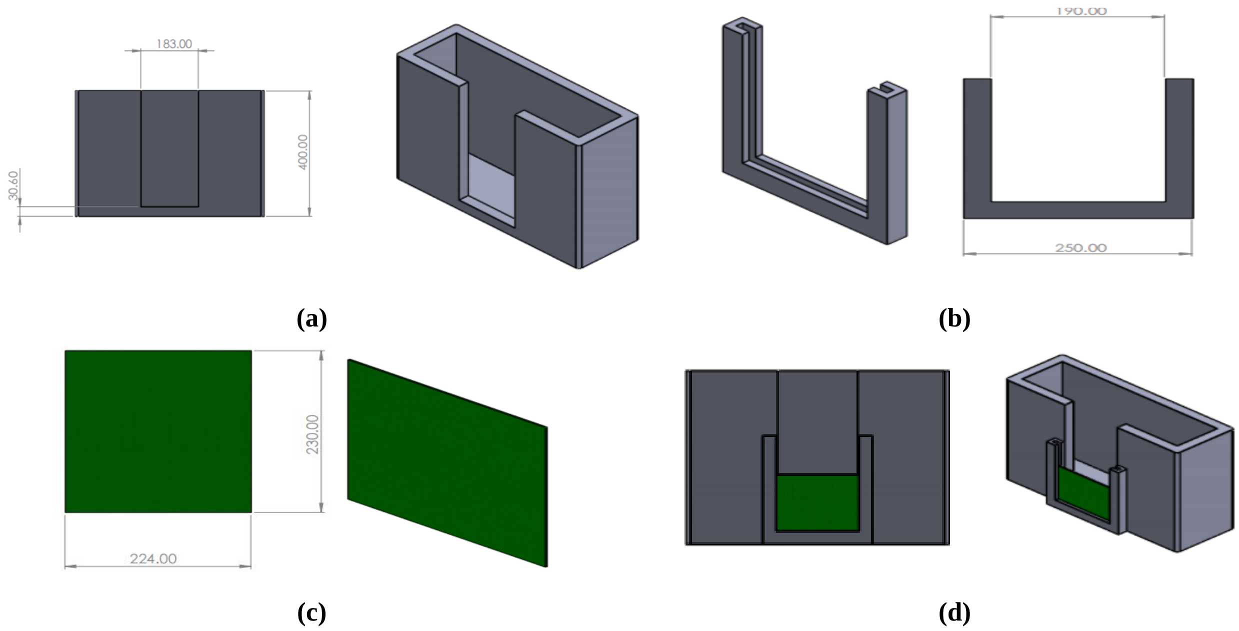

Fig. 3 *(a) Dimensions of the prototype, (b) the detailing dimension of the u-structure, (c) Dimension of the canvas, and (d) a comprehensive visual representation of the prototype flood barrier*

Fig. 3 (d) presents a comprehensive visual representation of the prototype flood barrier, showcasing its front view, side view, and a detailed 3-dimensional rendering. The front view provides a clear depiction of the barrier's frontal aspect, allowing for an understanding of its overall appearance and features from a forward perspective. The side view offers a valuable vantage point, revealing important structural elements, dimensions, and any additional components that may be attached to the barrier. Lastly, the 3-dimensional representation provides a holistic view of the prototype, enabling a thorough examination of its design, proportions, and spatial relationships. Together, these views in Fig. 3(d) facilitate a comprehensive understanding of the flood barrier's form and aid in the assessment of its efficacy and potential effectiveness in flood mitigation scenarios.

The prototype produced impeccably adheres to every specified requirement established. Prior to its production, we meticulously created a three-dimensional sketch of the project, carefully determining and detailing its precise dimensions. Fig. 4 shows the actual image of the prototype from the various sides of the design that have been carefully produced.

Fig. 4 *Prototype revealing both its (a) front view and (b) side view in parts*

The prototype underwent tests to evaluate its effectiveness as a flood barrier, focusing on two important aspects: leak detection and water resistance. The evaluation involves a flood barrier in a controlled experiment where water is applied to it, simulating a flood scenario. Fig. 5 visually illustrates this testing process, capturing the flood barrier prototype in action as it faces the water challenge. The results of this assessment will play an important role in measuring the barrier's performance and potential to effectively reduce flood incidents.

Fig. 5 *The flood barrier prototype undergoing water testing*

The test results clearly show the satisfactory performance of the Flood Barrier. It exhibits control over the water used, effectively resisting strong water pressure, with minimal seepage and acceptable deflection observed during severe flooding situations. The structural integrity of the barrier remained intact throughout the test, trapping floodwater efficiently without any signs of failure or leakage. The Flood Barrier's modular design has proven beneficial, facilitating easy installation and use. Additionally, the use of high-quality materials ensures both permeability and durability, increasing the barrier's overall effectiveness and lifespan. As a result, the prototype flood barrier system exhibits floodwater containment, stability, and adaptability. These results show that, with further optimization and refinement, the flood barrier system has great potential as a reliable solution for flood-prone areas. Its ability to control floods and maintain its position as a practical option to deal with the challenges posed by floods effectively.

4. Conclusion

In conclusion, flood barriers are an essential infrastructure component for protecting vulnerable areas from the destructive impacts of flooding. These barriers are designed to prevent or minimize floodwater from entering specific regions, safeguarding lives, properties, and critical infrastructure. The flood barriers offer several advantages. First and foremost, they provide immediate protection during flood events, reducing the risk of damage and loss. They can be constructed using a variety of materials, such as concrete, steel, or inflatable barriers, tailored to suit different environments and flood risk levels. Additionally, flood barriers can be temporary or permanent, offering flexibility in deployment based on the frequency and severity of flooding in each area. The flood barriers also contribute to long-term resilience and adaptation strategies. They serve as a visible reminder of flood risks, prompting communities and authorities to adopt comprehensive flood management plans, including land-use regulations, early warning systems, and evacuation protocols. Furthermore, flood barriers can be integrated with other flood protection measures, such as drainage systems, floodplain zoning, and natural or nature-based solutions, to create a holistic approach to flood risk reduction.

However, it is crucial to acknowledge the limitations of flood barriers. They are not foolproof and may not be able to withstand extremely severe flooding events or unexpected circumstances. Additionally, their construction and maintenance can be costly, requiring substantial financial resources. Furthermore, flood barriers can alter the natural flow of rivers and impact ecosystems, necessitating careful environmental considerations and mitigation measures. Flood barriers are valuable tools in managing and mitigating flood risks. However, they should be viewed as part of a broader flood management strategy that encompasses various measures to ensure comprehensive and sustainable protection against floods. The integration of technological advancements, community engagement, and proactive planning are essential for maximizing the effectiveness of flood barriers and reducing the overall impact of flooding on vulnerable regions.

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Conflict of Interest

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

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

References

[1] Haziq Sarhan Rosmadi, Minhaz Farid Ahmed, Mazlin Bin Mokhtar & Chen Kim Lim (2023) Reviewing challenges of flood risk management in Malaysia, *Water, 15(13),* 1-21, https://doi.org/10.3390/w15132390

[2] Yi-Chang Chiang (2018) Exploring community risk perceptions of climate change - A case study of a flood-prone urban area of Taiwan, *Cities, 74,* 42-51, https://doi.org/10.1016/j.cities.2017.11.001

[3] Grabs, W., Tyagi, A. C., & Hyodo, M. (2007) Integrated flood management, *Water science and technology, 56(4), 97*-103.

[4] Mattia Bosoni, Barbara Tempels & Thomas Hartmann (2023) Understanding integration within the Dutch multi-layer safety approach to flood risk management, *International Journal of River Basin Management, 21(1),* 81-87, https://doi.org/10.1080/15715124.2021.1915321

[5] Daniela Molinari, Susanna Dazzi, Edoardo Gattai, Guido Minucci, Giulia Pesaro, Alessio Radice & Renato Vacondio (2021) Cost–benefit analysis of flood mitigation measures: a case study employing high-performance hydraulic and damage modelling, *Natural Hazards, 108,* 3061-3084, https://doi.org/10.1007/s11069-021-04814-6

[6] Dolor R. Enarevba & Karl R. Haapala (2023) A comparative life cycle assessment of expanded polystyrene and mycelium packaging box inserts, *Procedia CIRP, 116,* 654-659, https://doi.org/10.1016/j.procir.2023.02.110

[7] Yafei Zhang, Taihao Fan, Pengbo Zhang & Yihua Dou (2023) Structural design and sealing performance analysis of a nanofluidic self-heating unsealing rubber cylinder, *Energies, 16,* 1-11, https://doi.org/10.3390/en16134890

[8] Xu, Y., Bai, Y., Fang, P., Yuan, S., & Liu, C. (2019) Structural analysis of fibreglass reinforced bonded flexible pipe subjected to tension, *Ships and Offshore Structures, 14(7),* 777-787.

[9] Stevens, L. E., Schenk, E. R., & Springer, A. E. (2021) Springs ecosystem classification, *Ecological Applications, 31(1),* e2218.