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Study On the Design and Materials for A Temporary Flood Barrier as A Flood Control Initiative in Mitigating Residential Areas

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Abstract: *This research aimed to identify the most suitable flood barrier to prevent floodwater from entering residential areas. Temporary flood barriers made from tarpaulin canvas and neoprene rubber sheet were tested for their robustness. The barriers showed zero leakage, displacement, and water splash. The neoprene product took 10 minutes to install, while the tarpaulin canvas took 6 minutes. The barriers had heights of 0.15 m, 0.30 m, and 0.5 m, with a length of 3 m. The maximum water volume retained was 1.425 m3, and the minimum was 0.428 m3. The study compared the resilience of PVC tarpaulin and neoprene rubber sheets. This abstract informs researchers about the study's objectives and findings in flood control initiatives for residential areas.*

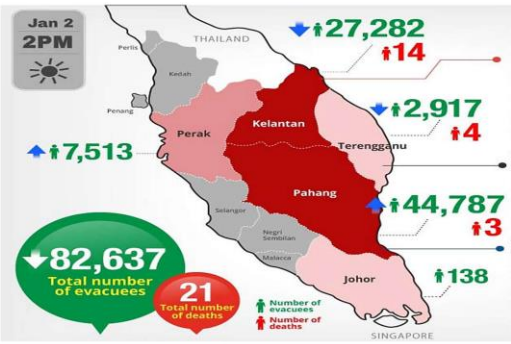
Keywords: Flood barrier; Temporary flood control; PVC Tarpaulin; Neoprene Rubber Sheets; Residential Flood Mitigation

1. INTRODUCTION

Flooding is a significant natural disaster that poses a threat to lives, infrastructure, and the economy in many regions, including Malaysia. The country has experienced severe flooding in recent years, such as the devastating floods in 2014 that affected numerous states and caused significant damage. Temporary flood barriers have emerged as a potential solution for mitigating the impacts of flooding and protecting residential areas. These barriers aim to control the flow of floodwater and prevent it from entering homes and other buildings. This technical paper focuses on the research and development of temporary flood barriers in Malaysia, specifically addressing the problem statement, previous solutions, and the gaps that need to be addressed.

Several important articles and recent review articles have contributed to the understanding of flood barriers and their effectiveness in flood mitigation. For instance, conducted a comprehensive study on flood disasters in Malaysia, highlighting the need for effective flood control measures [1]. They discussed the sudden rise of water levels during floods, which often caught residents off guard. This study emphasizes the importance of implementing suitable flood barriers to minimize the impact of flooding. The consequences of the 2014 floods in Malaysia, particularly the disruption of train services and the displacement of thousands of individuals [2]. This research underscores the urgent need for effective flood barriers to protect critical infrastructure and prevent the displacement of residents. Furthermore, studies such as shed light on the economic and environmental impacts of flooding in Malaysia, emphasizing the negative effects on sectors like agriculture and the depletion of water resources [3]. These studies highlight the importance of developing efficient flood barriers to safeguard the economy and the environment.

To develop effective temporary flood barriers, it is crucial to evaluate different types of barriers and assess the suitability of materials for their construction [4]. Additionally, the optimal size and design considerations for temporary flood barriers in densely populated residential areas need to be investigated. This research aims to address these challenges and provide guidelines and recommendations for the implementation and maintenance of temporary flood barriers in Malaysia. If intensively developed lowland regions with significant flooding risk intersect with key places for biodiversity conservation, it might be appropriate to strive to harmonise biodiversity conservation with human development in human-occupied lowland areas [5]. To achieve these objectives, a research methodology that combines literature review, data analysis, and possibly field experiments will be employed. In-depth understanding of the existing hazards and dangers throughout a river basin and flood-prone locations is required for effective and efficient flood risk management [6]. This approach will provide a comprehensive understanding of the effectiveness of various flood barrier solutions. It will also consider parameters such as floodwater levels, hydrodynamic forces, barrier dimensions, and suitable materials to withstand these forces. By conducting this research, valuable insights can be gained to inform the development and implementation of effective temporary flood barriers in Malaysia. The flood tragedy was caused by a sudden increase in the Red River's water level, and rising urbanisation, economic development, and long-term climate unpredictability have exacerbated the river flooding problem, putting people and property at risk [7]. A historical perspective on flood barriers, tracing their origins back to ancient civilizations and discussing their evolution into modern structures using advanced materials [8]. Flood barriers worldwide showcase their role in protecting communities from the devastating effects of floods [9]. These review articles offer valuable insights into the development and significance of flood barriers, providing a foundation for further research in this field. Based on Figure 1(a), it shows the flood areas that occurred in several states in Malaysia in 2014. Figure 1(b) depicts the state of water rising in a house with an estimated height of 15 cm. Next, Figure 1(c) illustrates the situation after the flood subsided in some of the areas involved.



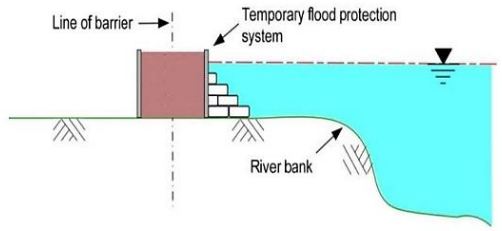
(a)

(b)

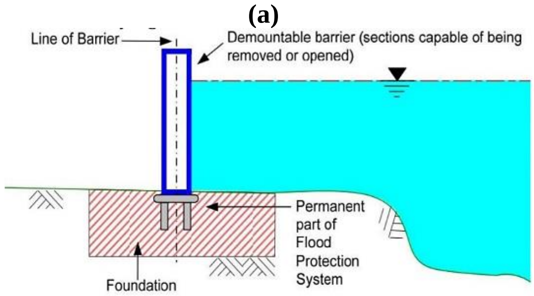
(c)

Fig. 1. Affected areas caused by 2014 flood (a) Flood area (b) Flood in house (c) House clean process [3]

Flood protection systems encompass a variety of measures aimed at preventing or mitigating the impacts of flooding. These measures range from physical barriers like levees, flood walls, and dams to non-structural approaches such as early warning systems, evacuation plans, and flood insurance. The overarching objective of a flood protection system is to diminish the risk of flooding and its consequences on individuals, assets, and the environment. Strategies employed in such systems involve flood risk assessment, mapping, land use planning, and effective floodplain management, with the specific measures chosen depending on the location, flood risk nature, and available resources [10]. Figure 2(a) illustrates a temporary flood protection system, composed of removable flood protection products installed entirely during a flood event and subsequently removed. Key reasons for opting for temporary solutions include insufficient economic justification for permanent or demountable systems, the management of flood risks exceeding permanent protection standards, and the interim use during the development or construction of a permanent or demountable system. A demountable flood protection system, shown in Figure 2(b), is a movable solution that can be pre-installed and activated during a flood or partially installed into pre-constructed foundations. It offers dual functionality, allowing access while having the defense pre-installed. This design addresses factors like temporary and permanent elements, foundation attributes, and connections with the underlying surface. Figure 2(c) shows a flood embankment, akin to a flood wall but often without a cut-off barrier, relying on its base width to prevent seepage, unless the soil is highly permeable. A soak dike, near the embankment's foot, collects surface seepage.



(a)



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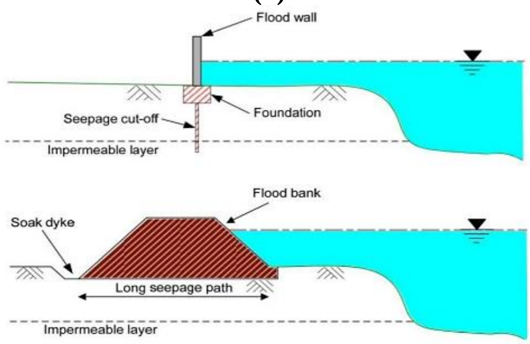


(c)

Fig. 2. Flood barrier protection system (a) Temporary protection (b) Demountable protection (c) Permanent protection [10]

The problem statement revolves around the need for effective flood barriers in Malaysia to mitigate the impacts of flooding and protect residential areas. Previous solutions to address this problem have primarily focused on traditional flood control measures such as dikes, dams, and weirs. While these solutions have provided some degree of protection, they often have limitations in terms of their flexibility, scalability, and adaptability to changing flood conditions. Traditional flood control measures may not be suitable for densely populated residential areas or areas with limited space for infrastructure development. These limitations highlight the gaps in the current approach to flood mitigation, necessitating the development of innovative and temporary flood barriers that can offer effective protection to residential areas in Malaysia. The temporary flood barriers should consider factors such as size, suitable materials, and the ability to withstand hydrodynamic forces exerted by floodwaters.

2. METHODOLOGY

The methodology employed in this study is to achieve the research objectives. The methodology was carefully designed and implemented to ensure a systematic and rigorous approach to the research process. This chapter outlines the steps followed, from the initial literature review to the data analysis and interpretation of results.

The methodology involved the identification of suitable design parameters for the frame and covering materials of the flood barriers. Additionally, velocity of water flow tests was conducted to measure various parameters such as leakage, displacement, water splash, and time of installation. The collected data were analyzed to evaluate the performance of the flood barriers. This method concludes with a summary of the results and provides recommendations based on the findings.

2.1 Frame

The frame serves as the structural backbone of the barriers and plays a critical role in their overall performance and durability. The frame was designed to possess key characteristics such as strength, durability, flexibility, ease of installation, and compatibility with the chosen covering materials. Strength was a paramount consideration, ensuring that the frame could withstand high water pressures without buckling or collapsing. Durability was another crucial aspect, with materials selected to resist corrosion, degradation, and deterioration over time. Flexibility was incorporated into the design to facilitate easy installation and removal of the barriers, accommodating variations in installation sites. The frame's size and shape were carefully determined to provide adequate coverage and adaptability to different settings. Compatibility with the chosen covering materials, such as neoprene and tarpaulin, was also prioritized to ensure a secure attachment and overall stability of the flood barriers. By addressing these design features, this study aimed to enhance the effectiveness and performance of the flood barriers in mitigating the impact of flooding events. Table 1 shows the specifications used to produce temporary flood barrier frames. In addition, Figure 3 shows the detailed measurements of the produced temporary flood barrier frame.

Table 1 Frame Specifications

		Frame
Material	:	Steel
Frame type	:	Rectangular
Dimensions	:	Height : 620 mm Width : 45 mm Length : 910 mm
Frame connection	:	MIG Welding
Steel thickness	:	1 mm
Additional support	:	Stainless steel, size 12.7 mm, thickness : 1.5 mm
Installation method	:	Manual Jack Welded
Bolt and nut	:	Size : M10 Spanner Size : 14 mm Can use Adjustable Spanner
Finishing	:	Anti-rust Paint

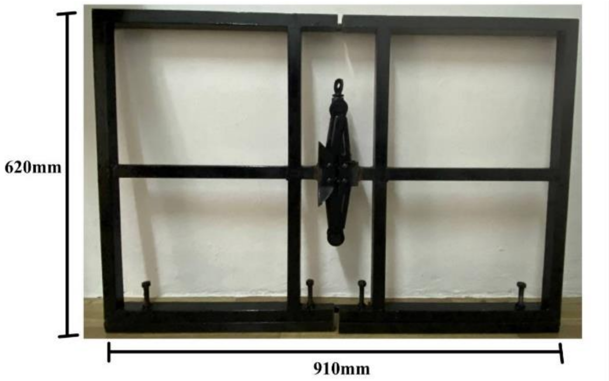


Figure 3 Frame of temporary flood barrier

2.2 Tarpaulin Canvas

Tarpaulin canvas as a covering material for the flood barriers was investigated. The canvas tarpaulin selected for this study was specifically chosen to fit the plate on the frame, with a size of 2 meters wide and 2 meters high in a square shape. This type of canvas tarpaulin is commonly used for water pools and is known for its durability and resistance to damage and rotting. While the canvas tarpaulin is impermeable, it is not entirely waterproof. However, it is considered a superior solution for covering various tasks and events. Canvas awnings made from 100% PVC tarpaulin are an environmentally friendly alternative to polyethylene sheets, offering water resistance, breathability, and durability. Table 2 displays the available thickness options for tarpaulin canvas designed for use in flood barrier applications. Figure 4 showcases the utilized canvas tarpaulin product with a size of 2m x 2m.

Table. 2 Tarpaulin canvas [11]

GSM	MONTHS
280	1
300	1 – 3
320	3 – 6
380	6 – 9
420 – 440	9 – 12
510	Around 1 year


Fig. 4 Tarpaulin canvas

2.3 Neoprene Rubber Sheet

Neoprene rubber, a synthetic polymer, is widely recognized for its outstanding physical and chemical characteristics. It is remarkable flexibility spans a broad temperature spectrum, maintaining pliability in both high and low-temperature conditions. Notable for its resistance to heat, oils, chemicals, and ozone, neoprene proves highly durable in diverse industrial applications and outdoor settings. The material's resilience to weathering and ozone further enhances its suitability for outdoor use, particularly in applications requiring effective moisture sealing. With excellent physical toughness and abrasion resistance, neoprene is a common choice for manufacturing gaskets, hoses, wetsuits, protective gear, industrial belts, and automotive components. Its elasticity allows it to stretch and return to its original shape, contributing to its effectiveness in sealing applications. Neoprene also exhibits strong adhesive properties, making it an ideal material for bonding applications. Widely utilized in construction, electronics, marine industries, and beyond, neoprene rubber stands out as a reliable and durable material capable of performing well in challenging environments. Table 3 provides the specification standard for neoprene rubber sheets. Figure 5 shows the size of the neoprene rubber sheet used for the flood barrier.

Table 3 Specification standard for neoprene rubber sheet [12]

Duorometer (Shore A±5)	Tensile Strength		Elongation	Approx. Weight (1/8", 3.2mm)		Temp. Range	
	PSI	Kg/ cm^2	%	Lbs/ ft^2	Kg/ m^2	°F	°C
50	850	60	450	0.90	4.40		
60	1000	70	400	0.94	4.60	-20~190	-28~87
70	1000	70	300	0.94	4.60		
80	1000	70	200	1.00	4.90		

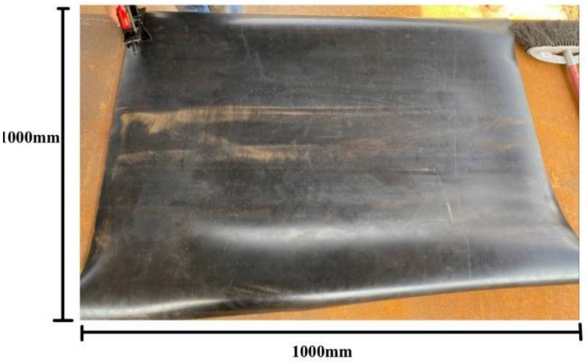


Fig. 5 Neoprene rubber sheet

2.4 Testing Location

For the selection of the test site, the researcher opted to conduct testing on the rooftop (FKAAB), chosen for its susceptibility to runoff during rainfall. Accordingly, a channel design, aligned with the dimensions of the temporary flood barrier product, was implemented. Testing will take place on a sunny day to ensure a dry environment, given that installation necessitates such conditions. Figure 6 visually represents the testing location on the Rooftop, FKAAB, UTHM.

Fig. 6 Location of testing (FKAAB, UTHM)

3. RESULT AND ANALYSIS

The importance of data analysis is emphasized as it provides valuable insights gained from the literature review. The data collection process involved conducting tests using current flow meter equipment over two days, with varying water levels and flow velocities. Graphical velocity analysis was used to visualize the maximum and minimum water velocities observed during the test. Each test that has been carried out will be given results and will be analyzed to ensure that both objectives are achieved. The section concludes by summarizing the findings, including maximum and minimum values and averages, which offer valuable information about the performance characteristics of flood barrier products. Overall, it serves as an important introduction to the process of data analysis, paving the way for further discussion and conclusions in the paper.

3.1 Collected Data

The data acquisition process encompassed a two-day period, with the initial day being subject to inclement weather conditions, while the subsequent day offered a highly advantageous climate for data compilation pertaining to the flood barrier tarpaulin canvas and neoprene rubber sheet. The tests were meticulously executed, with the Neoprene Rubber and Tarpaulin Canvas Flood Barriers being subjected to three trials each, encompassing varying water level heights of 0.15m, 0.30m, and 0.5m. Furthermore, the limitations of the current flow meter, which facilitated measurements solely up to 6 m/s, necessitated capturing flow meter readings at distinct velocity thresholds: 0-1.9 m/s, 2-3.9 m/s, and 4-5.9 m/s. Each test category was replicated five times, ensuring diverse temporal intervals. The resultant data, meticulously documented in Table 4 for the Neoprene Flood Barrier and Tarpaulin Canvas Flood Barrier, comprehensively encapsulate the pertinent variables, encompassing water level heights, flow meter readings, and the quantity of tests conducted. Consequently, this meticulously collected data forms the bedrock for subsequent meticulous analysis, comparisons, and informed conclusions regarding the efficacy of these flood barrier products in the context of flood mitigation.

Table. 4 Data collection of testing

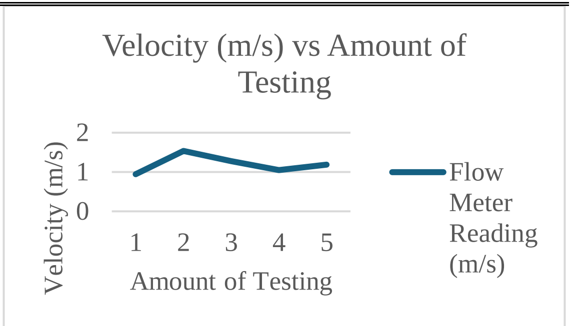
Product Name	Testing No.	Water High (m)	Length (m)	Volume Water (m3)	Flow Meter Reading Range (m/s)	Set of Flow Meter Reading (m/s) 1 F.M Reading (m/s)	2 F.M Reading (m/s)	3 F.M Reading (m/s)	4 F.M Reading (m/s)	5 F.M Reading (m/s)	Average of Flow Meter Reading (m/s)
		0.15	3	0.428	0 – 1.9	0.944	1.536	1.278	1.051	1.19	1.1998
	1	0.15	3	0.428	2 – 3.9	2.689	2.293	2.342	2.326	2.139	2.3578
		0.15	3	0.428	4 – 5.9	5.777	5.269	5.47	4.018	5.318	5.1704
		0.30	3	0.855	0 – 1.9	0.490	1.237	0.985	0.403	1.495	0.922
T.F.B (Neoprene)	2	0.30	3	0.855	2 – 3.9	2.821	2.821	3.486	2.821	2.821	2.954
		0.30	3	0.855	4 – 5.9	4.700	4.969	5.777	5.777	5.479	5.3404
		0.50	3	1.425	0 – 1.9	1.636	1.821	1.864	0.321	1.836	1.4956
	3	0.50	3	1.425	2 – 3.9	2.190	2.908	3.736	2.821	2.821	2.8952
		0.50	3	1.425	4 – 5.9	5.777	4.043	4.587	5.777	5.562	5.1492
		0.15	3	0.428	0 – 1.9	0.819	1.155	0.703	0.31	1.741	0.9456
	1	0.15	3	0.428	2 – 3.9	3.94	3.462	2.821	3.083	2.587	3.1786
		0.15	3	0.428	4 – 5.9	5.777	5.257	4.68	5.489	5.777	5.396
		0.30	3	0.855	0 – 1.9	0.883	0.905	1.436	1.759	1.743	1.3452
T.F.B (Canvas)	2	0.30	3	0.855	2 – 3.9	3.208	2.189	2.654	3.816	3.101	2.9936
		0.30	3	0.855	4 – 5.9	5.777	5.777	5.597	4.041	4.467	5.1318
		0.50	3	1.425	0 – 1.9	0.714	1.639	1.129	1.614	1.686	1.3564
	3	0.50	3	1.425	2 – 3.9	3.095	2.821	2.486	2.392	2.821	2.723
		0.50	3	1.425	4 – 5.9	5.777	5.383	4.677	4.965	4.314	5.0232

3.2 Velocity and Flow Water

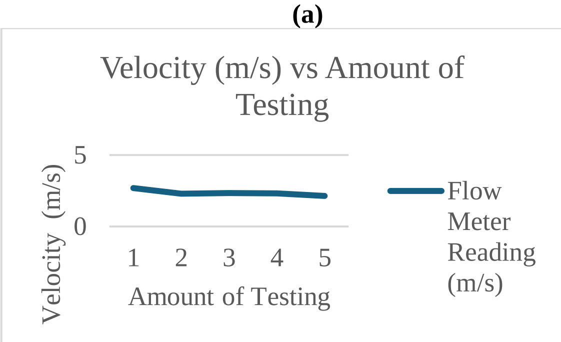
Velocity and flow of water based on the collected data from the tests conducted on the Neoprene Rubber and Tarpaulin Canvas Flood Barriers. The velocity and flow of water are important parameters to consider when evaluating the performance of flood barriers in mitigating flood situations. The analysis involved examining the relationship between flow meter readings and the amount of testing conducted for different flow velocity ranges. Graphical representations were used to illustrate the maximum and minimum water velocities observed during the tests. The analysis of velocity and flow water data provides valuable insights into the behavior of the flood barriers under different flow conditions, helping to assess their effectiveness and inform flood mitigation strategies.

3.2.1 Neoprene Rubber Sheet

Neoprene Rubber Sheet Flood Barrier performs under different water velocity scenarios. By subjecting the flood barrier to various flow conditions, researchers aimed to understand its ability to withstand and mitigate the impact of flowing water. The testing process likely involved controlled experiments where the water velocity was adjusted and measured, allowing for observations and data collection. Neoprene Rubber Sheet Flood Barrier performs under different water velocity scenarios. By subjecting the flood barrier to various flow conditions, researchers aimed to understand its ability to withstand and mitigate the impact of flowing water. The testing process likely involved controlled experiments where the water velocity was adjusted and measured, allowing for observations and data collection.



(a)



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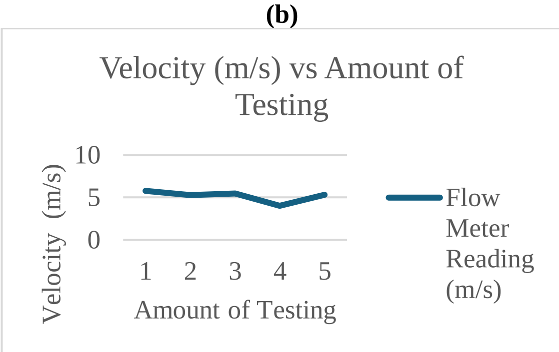


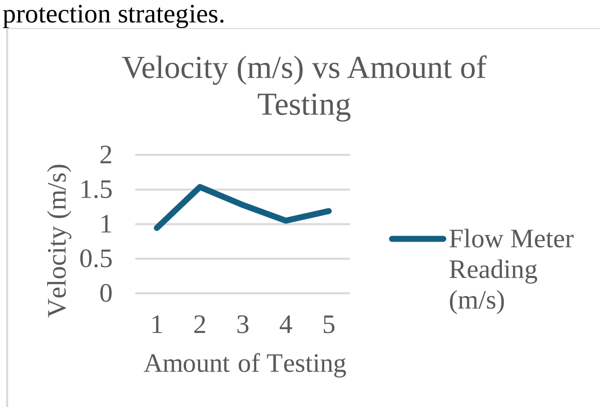
(c)

Fig. 7 Velocity and flow graph neoprene rubber sheet(a) Test 1 0.15m (b) Test 1 0.30m (c) Test 1 0.50m

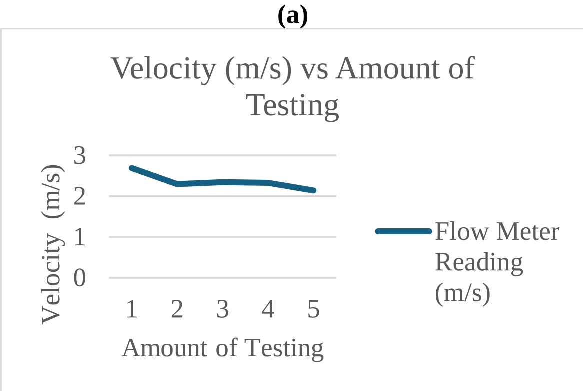
Based on Test 1 the graphs in Figure 8(a), Figure 8(b), and Figure 8(c), the researcher found that the maximum reading from the current flow meter successfully obtained was 5.777 m/s. The situation varies with the current, depending on the water pressure against the neoprene flood barrier. In Figure 8(a), in the range of 0-1.9 m/s, the maximum flow speed obtained is 1.536 m/s, with a minimum value of 0.944 m/s. The average for these values is 1.199 m/s. In Figure 8(b), in the range of 2-3.9 m/s, the maximum value is 2.689 m/s, and the minimum is 2.139 m/s, with an average value of 2.358 m/s. Figure 8(c) has a maximum value of 5.777 m/s and a minimum of 4.018 m/s, with an average obtained value of 5.170 m/s.

3.2.1 Tarpaulin Canvas

The testing of the flood barrier involved subjecting it to various conditions and scenarios without specifying specific values. The purpose of the testing was to assess the effectiveness of the Tarpaulin Canvas Flood Barrier in mitigating flood situations. The collected data from the testing process was analyzed to understand the behavior and performance of the flood barrier. While the specific details of the testing procedure and equipment used are not provided in the truncated content, it can be inferred that the testing was conducted systematically to gather relevant information. The analysis of the data aimed to provide insights into how the Tarpaulin Canvas Flood Barrier interacts with different conditions, allowing for informed conclusions and further improvements in flood protection strategies.



(a)



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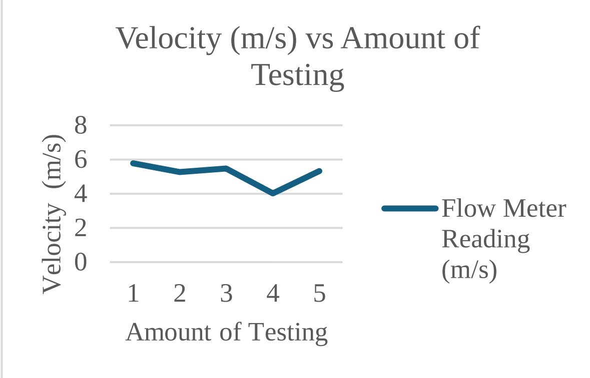


(c)

Fig. 8 Velocity and flow graph tarpaulin canvas (a) Test 1 0.15m (b) Test 1 0.30m (c) Test 1 0.50m.

For Test 1 of the temporary flood barrier with canvas tarpaulin, Figure 9(a) shows the maximum velocity reading in the 0-1.9 m/s range is 1.741 m/s, while the minimum reading is 0.310 m/s. The average velocity for this range is 0.945 m/s. Figure 9(b) shows the 2-3.9 m/s range, the maximum reading is 3.940 m/s, and the minimum reading is 2.587 m/s, with an average velocity of 3.178 m/s. Figure 9(c) shows the 4-5.9 m/s range, the maximum reading is 5.777 m/s, the minimum reading is 4.680 m/s, and the average velocity is 5.396 m/s.

3.3 Leakage Analysis

Data collected from six studies on temporary flood barriers constructed from neoprene rubber and tarpaulin canvas for leakage assessment is presented in Table 5. The findings reveal that, in each conducted test, no leakage was observed in either of the material covers. This indicates a robust sealing mechanism, ensuring a watertight enclosure with no spaces for water infiltration along the sides or bottom. The effectiveness of this sealing is credited to the rubber tape, which plays a crucial role in maintaining the integrity of the water reservoir under examination. Figure 9 visually confirms the absence of leakage during testing for the neoprene flood barrier.

Table 5. Leakage data

Product Name	Test No.	Water High (m)	Length (m)	V. Water (m3)	F.M Range (m/s)	Avg. F.M (m/s)	Leakage (ml)
T.F.B (Neoprene)	1	0.15	3	0.428	0 – 1.9	1.1998	0
		0.15	3	0.428	2 – 3.9	2.3578	0
		0.15	3	0.428	4 – 5.9	5.1704	0
	2	0.30	3	0.855	0 – 1.9	0.922	0
		0.30	3	0.855	2 – 3.9	2.954	0
		0.30	3	0.855	4 – 5.9	5.3404	0
	3	0.50	3	1.425	0 – 1.9	1.4956	0
		0.50	3	1.425	2 – 3.9	2.8952	0
		0.50	3	1.425	4 – 5.9	5.1492	0
T.F.B (Canvas)	1	0.15	3	0.428	0 – 1.9	0.9456	0
		0.15	3	0.428	2 – 3.9	3.1786	0
		0.15	3	0.428	4 – 5.9	5.396	0
	2	0.30	3	0.855	0 – 1.9	1.3452	0
		0.30	3	0.855	2 – 3.9	2.9936	0
		0.30	3	0.855	4 – 5.9	5.1318	0
	3	0.50	3	1.425	0 – 1.9	1.3564	0
		0.50	3	1.425	2 – 3.9	2.723	0
		0.50	3	1.425	4 – 5.9	5.0232	0

Figure 9 Neoprene flood barrier

3.4 Displacement Analysis

Displacement data was established with a baseline of 20 cm from the flood barrier. Analysis of Table 6 reveals no displacement during testing for high water levels of 0.15 m, 0.30 m, and 0.5 m. Consequently, the displacement recorded for each scenario is zero meters. Figure 10 visually represents the baseline positioned 20 cm from the flood barrier, further illustrating the absence of displacement.

Table 6 Displacement data

Product Name	Test No.	Water High (m)	Length (m)	V. Water (m3)	F.M Range (m/s)	Avg. F.M (m/s)	Displacement (m)
		0.15	3	0.428	0 – 1.9	1.1998	0
	1	0.15	3	0.428	2 – 3.9	2.3578	0
		0.15	3	0.428	4 – 5.9	5.1704	0
T.F.B (Neoprene)		0.30	3	0.855	0 – 1.9	0.922	0
	2	0.30	3	0.855	2 – 3.9	2.954	0
		0.30	3	0.855	4 – 5.9	5.3404	0
		0.50	3	1.425	0 – 1.9	1.4956	0
	3	0.50	3	1.425	2 – 3.9	2.8952	0
		0.50	3	1.425	4 – 5.9	5.1492	0
		0.15	3	0.428	0 – 1.9	0.9456	0
	1	0.15	3	0.428	2 – 3.9	3.1786	0
		0.15	3	0.428	4 – 5.9	5.396	0
T.F.B (Canvas)		0.30	3	0.855	0 – 1.9	1.3452	0
	2	0.30	3	0.855	2 – 3.9	2.9936	0
		0.30	3	0.855	4 – 5.9	5.1318	0
		0.50	3	1.425	0 – 1.9	1.3564	0
	3	0.50	3	1.425	2 – 3.9	2.723	0
		0.50	3	1.425	4 – 5.9	5.0232	0

Fig. 10 Baseline 20cm from flood barrier

3.5 Water Splash

For the collection of data obtained from the water splash, it was found that there was no water splash observed when the testing was conducted. The value obtained was 0 ml for every three tests for both types of temporary flood barriers, neoprene rubber, and tarpaulin canvas. Table 7 shows the data water splash got after the testing process. Figure 11 shows the tarpaulin canvas has no water splash from top.

Table 7. Water splash data

Product Name	Test No.	Water High (m)	Length (m)	V. Water (m3)	F.M Range (m/s)	Avg. F.M (m/s)	Water Splash (ml)
		0.15	3	0.428	0 – 1.9	1.1998	0
	1	0.15	3	0.428	2 – 3.9	2.3578	0
		0.15	3	0.428	4 – 5.9	5.1704	0
T.F.B (Neoprene)		0.30	3	0.855	0 – 1.9	0.922	0
	2	0.30	3	0.855	2 – 3.9	2.954	0
		0.30	3	0.855	4 – 5.9	5.3404	0
		0.50	3	1.425	0 – 1.9	1.4956	0
	3	0.50	3	1.425	2 – 3.9	2.8952	0
		0.50	3	1.425	4 – 5.9	5.1492	0
		0.15	3	0.428	0 – 1.9	0.9456	0
	1	0.15	3	0.428	2 – 3.9	3.1786	0
		0.15	3	0.428	4 – 5.9	5.396	0
T.F.B (Camvas)		0.30	3	0.855	0 – 1.9	1.3452	0
	2	0.30	3	0.855	2 – 3.9	2.9936	0
		0.30	3	0.855	4 – 5.9	5.1318	0
		0.50	3	1.425	0 – 1.9	1.3564	0
	3	0.50	3	1.425	2 – 3.9	2.723	0
		0.50	3	1.425	4 – 5.9	5.0232	0

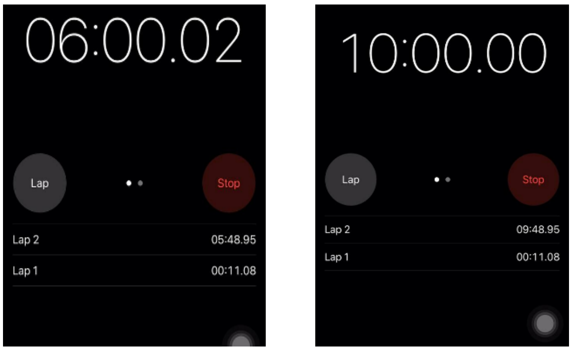
Fig. 11 Tarpaulin canvas test

3.6 Time of Installing

Concerning the installation of temporary flood barriers, the time required varies based on the type of covering either tarpaulin canvas or neoprene flood barrier. According to Table 8, it is evident that the installation time for tarpaulin canvas is notably quicker compared to the use of neoprene rubber sheet material as a covering. This difference is attributed to the 6 mm thickness of neoprene rubber, which directly increases the complexity of installation. In contrast, the thinner thickness of tarpaulin canvas makes it lighter and more straightforward to install. Figure 12(a) illustrates the installation time of 6 minutes for the tarpaulin canvas flood barrier, while Figure 12(b) depicts the installation time for the neoprene rubber sheet.

Table 8 Time of installing data.

Product Name	Test No.	Water High (m)	Length (m)	V. Water (m3)	F.M Range (m/s)	Avg. F.M (m/s)	Time of Installing (min)
T.F.B (Neoprene)	1	0.15	3	0.428	0 – 1.9	1.1998	10
		0.15	3	0.428	2 – 3.9	2.3578	
		0.15	3	0.428	4 – 5.9	5.1704	
	2	0.30	3	0.855	0 – 1.9	0.922	
		0.30	3	0.855	2 – 3.9	2.954	
		0.30	3	0.855	4 – 5.9	5.3404	
	3	0.50	3	1.425	0 – 1.9	1.4956	
		0.50	3	1.425	2 – 3.9	2.8952	
		0.50	3	1.425	4 – 5.9	5.1492	
T.F.B (Canvas)	1	0.15	3	0.428	0 – 1.9	0.9456	6
		0.15	3	0.428	2 – 3.9	3.1786	
		0.15	3	0.428	4 – 5.9	5.396	
	2	0.30	3	0.855	0 – 1.9	1.3452	
		0.30	3	0.855	2 – 3.9	2.9936	
		0.30	3	0.855	4 – 5.9	5.1318	
	3	0.50	3	1.425	0 – 1.9	1.3564	
		0.50	3	1.425	2 – 3.9	2.723	
		0.50	3	1.425	4 – 5.9	5.0232	



(a) **(b)**

Fig. 12 Time installing flood barrier (a) Tarpaulin canvas (b) Neoprene rubber sheet.

3.7 Summary Analysis Data

In summarizing the data analysis, it is evident that both neoprene rubber sheet and tarpaulin serve the same purpose but come with distinct requirements. Neoprene rubber sheet flood barriers, despite being more expensive due to the thickness of the material, demonstrated resilience. As per Table 9, the installation process takes 10 minutes, reflecting the challenge posed by the thickness of the rubber. Despite reaching a maximum velocity of 5.777 m/s at a water height of 0.50 meters, the neoprene rubber sheet accommodated the conditions without any leakage or issues. In comparison, the tarpaulin flood barrier Table 10 had a somewhat easier installation process, taking 6 minutes, thanks to its lighter and thinner material. However, in terms of durability, the neoprene rubber sheet outperformed. Both products were tested at a water speed of 5.777 m/s at a height of 0.50 meters, demonstrating the neoprene rubber sheet's resilience without experiencing any failures.

Table 9 Summary data neoprene flood barrier

Temporary Flood Barrier (Neoprene)								
Test No.	Range	Max F.M (m/s)	Min F.M (m/s)	Avg. (m/s)	Displacement (m)	Leakage (ml)	Water Splash	Time of Installing (min)
1	0 – 1.9	1.536	0.944	1.1998	0	0	0	10
	2 – 3.9	2.689	2.139	2.3578	0	0	0	
	4 – 5.9	5.777	4.018	5.1704	0	0	0	
2	0 – 1.9	1.864	0.321	0.922	0	0	0	
	2 – 3.9	3.486	2.821	2.954	0	0	0	
	4 – 5.9	5.777	4.700	5.3404	0	0	0	
3	0 – 1.9	1.864	0.321	1.4956	0	0	0	
	2 – 3.9	3.736	2.190	2.8952	0	0	0	
	4 – 5.9	5.777	4.043	5.1492	0	0	0	

Table 10 Summary data tarpaulin canvas

Temporary Flood Barrier (Tarpaulin Canvas)								
Test No.	Range	Max F.M (m/s)	Min F.M (m/s)	Avg. (m/s)	Displacement (m)	Leakage (ml)	W. Splash	Time of Installing (min)
1	0 – 1.9	1.741	0.310	0.9456	0	0	0	6
	2 – 3.9	3.940	2.587	3.1786	0	0	0	
	4 – 5.9	5.777	4.680	5.396	0	0	0	
2	0 – 1.9	1.759	0.883	1.3452	0	0	0	
	2 – 3.9	3.816	2.189	2.9936	0	0	0	
	4 – 5.9	5.777	4.041	5.1318	0	0	0	
3	0 – 1.9	1.686	0.714	1.3564	0	0	0	
	2 – 3.9	3.095	2.392	2.723	0	0	0	
	4 – 5.9	5.777	4.314	5.0232	0	0	0	

4. CONCLUSION

In conclusion, this study aimed to design and evaluate the performance of two types of flood barriers made from tarpaulin canvas and neoprene rubber. The objectives were successfully achieved by conducting various tests to assess the durability and robustness of the proposed flood barriers. The results showed that both the tarpaulin canvas and neoprene rubber flood barriers exhibited excellent performance in terms of leakage, displacement, water splash, and installation time. The tests demonstrated that these barriers effectively prevented floodwater from entering residential areas, thereby mitigating potential damage and losses. Based on the data analysis, it can be concluded that both types of flood barriers are suitable for temporary flood protection, providing user-friendly and cost-effective solutions. The study recommends further research and evaluation to optimize the design and material properties of flood barriers for enhanced performance and long-term sustainability.

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