Journal of Advanced Research in Applied Sciences and Engineering Technology 33, Issue 2 (2024) 76-84

SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage: https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Undrained Shear Strength from Field Vane Shear Test (VST) of Soil at Shoreline Area

Nor Baizura Hamid[1], Mardiha Mokhtar[1,*], Mohd Effendi Daud[2], Aslila Abd Kadir[1], Masiri Kaamin[1], Mohamad Azim Mohammad Azmi[1], Suhaila Sahat[1], Syamsul Azrin Kamaruddin[1], Muhamad Syamil Sabri[2], Azreen Shafiqa Nabilla Azlan[2]

[1] Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia (Pagoh Campus), Pagoh Higher Education Hub, Jalan Panchor, 84600 Panchor, Johor, Malaysia
[2] Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, Malaysia

ARTICLE INFO

Article history:
Received 13 June 2023
Received in revised form 7 October 2023
Accepted 14 October 2023
Available online 31 October 2023

Keywords:
Undrained shear strength; shoreline area; high tide; medium tide; vane shear test

ABSTRACT

The effect of soil shear strength at the shoreline area is the focus of this study. Pantai Punggur, Batu Pahat, Johor, has been chosen as the subject location for the soil shear strength investigation. It is located on the west coast of Johor, with latitudes ranging from 1.62° to 1.87° N and longitudes ranging from 102.78° to 103.19° E. The purpose of this study is to use a field vane shear test (VST) to determine the undrained shear strength of shoreline areas. Soil samples were collected at specific locations known as Zones A, B, C, D, and E, and data for sediment shear strength was obtained from field vane shear test (VST) methods. From the undrained shear strength test at 0.5 m depth at high tide (HT) and medium tide (MT) data for December 2021, Zone A had a Cu reading of more than 4.5 kPa, followed by Zones B, C, and D, and lowest at Zone E. Next, in the December 2021 data at the HT level, Zone A has a Cu reading greater than 4.5 kPa at 0.5 m and 1.0 m, while other Zones have readings less than 3.0 kPa. It can be concluded that the depth of a part also influences the data in this study. When the depth increases, the shear strength of the data also increases. This study will serve as a benchmark for future conservation efforts. Based on the findings, more effective control measures for preserving and conserving coastal areas may be developed.

1. Introduction

Malaysia is one of the countries that receives significant rain and heat throughout the year because Malaysia is located near the Equator. Malaysia is in the continent of Southeast Asia and coordinates between Latitude 1°N and 7°N, and Longitude 100°E and 119°E near the South China Sea and the Strait of Malacca. The South China Sea separated these two regions by 640 km. Malaysia has a shoreline of 4,809 km, with more than 1,300 km of beaches diminishing [1].

A topography change can be estimated from a change in the shoreline due to sediment transport and the investigation of the shoreline has been carried out by various methods. A body of water's

* *Corresponding author.*
E-mail address: mardiha@uthm.edu.my

https://doi.org/10.37934/araset.33.2.7684

coast is a strip of land that is periodically covered or exposed by waves or tides [2]. Sediment transport is weathering-induced sedimentation, and the resulting degradation of such sediments results in the reshaping of landforms. Likewise, the deposition of the movement of sediments results in the formation and evolution of a diverse range of landforms. Furthermore, according to Sherman *et al.,* [3], the composition of sediment deposits reveals information about the process environment involved with their transport and deposition. The shoreline changes will be early detection of erosion. High rates of erosion are due to generally weak soil shear strength that indicate land loss related to poor soil quality as shown in Figure 1. In order to maintain the stability of the strength and stiffness of the soil for any building to be constructed, soil stabilization is crucial. Traditional soil stabilizers like cement, lime, and fly ash are separated from non-traditional ones including enzymes, liquid polymers, resins, and acids [4].

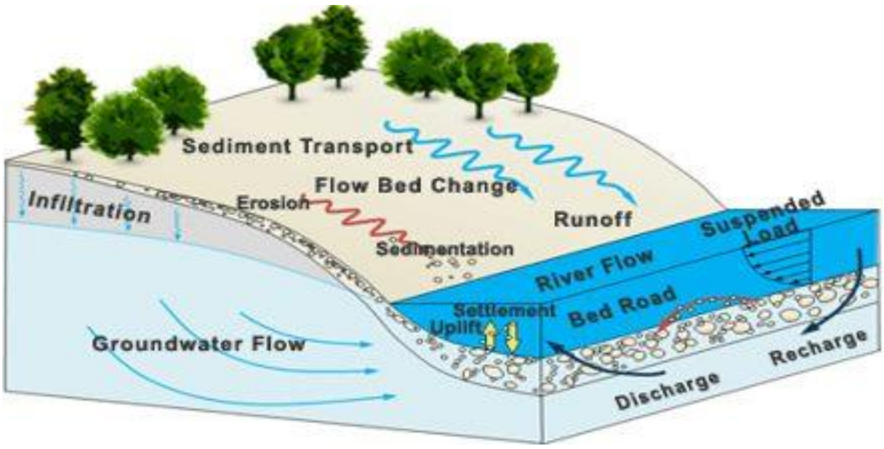


Fig. 1. Modes of sediment transport show the shoreline changes effect of erosion [2]

In addition to understanding more about sediment transport, it is essential always to understand the characteristics of the sediments. Researchers can determine some important facts from the properties of the sediment itself, such as the elements that contribute to sediment transport, the factors that will enhance the improvement of the sediment properties and the cognition of the underlying sediment after its property modification. Measurements of shear strength, particularly for cohesive sediment, are best conducted in the field in the first instance, because the extraction, transport, and storage of cores prior to analysis in the laboratory cause physical, chemical, and biological changes to the sediment characteristics that alter its shear strength. The results from strength test combined with shoreline changes analysis will provide an investigation on geomorphological forms and processes of coastal erosion [5].

The rate of coastal erosion varies according to sediment supply, climate, and ocean conditions. Coastal accretion occurs when the shoreline grows, and coastal erosion occurs when the shoreline recedes. When erosion threatens people's activities, it becomes a hazard. Erosion is classified into three types: critical, significant, and acceptable [6]. The active coastal zone is always striving for dynamic equilibrium. This can take a long time if some parts are highly resistant to erosion, but it can take a very short time if the active coastal zone is made up of loose sediment [7]. Only structural changes in hydrodynamic conditions, sediment supply, or subsoil motion can cause structural erosion. These changes could be the result of natural phenomena or human activity. Climate change, wave climate, and sediment supply are natural phenomena that influence structural change [8-13]. According to previous study [14], the average wave energy along the Malaysian coastline that faces the South China Sea ranges from 1.41 kW/m to 7.92 kW/m.

Therefore, this study will determine the rate of strength of the soil in the study area. A field vane shear test (VST) is performed on each soil sample, and multiple spots on the sample are evaluated to get the average torque angle and shear strength values. The relationship between the depth and the effect of shear strength will be determined.

2. Methodology

The study begins with the selection of a location, and Pantai Punggur was chosen as the study area. Pantai Punggur is one of the areas in Batu Pahat that has critical erosion [15]. Batu Pahat is an area with significant changes of coastline [16]. The erosion that takes place in the coastal area was categorized into three categories: critical, significant, and acceptable [17]. Coastal erosion is defined as the loss of coastal land due to the net removal of sediments from the shoreline, and this process is also called shoreline retreat. The erosion that occurs in the coastal area is mainly caused by the occurrence of natural disasters and anthropogenic impacts. This can be proved by the data from the 1985 National Coastal Erosion Study (NCES), which concluded that about 29% of the shoreline is eroding. The tide prediction for each day has been accessible on the website www.tide-forecast.com. Tidal water level predictions will be used during each site visit. Table 1 displays the predicted tidal water level and provides a time for tidal sampling.

Table 1
The low tide and high tide from November 2021 to December 2021

Date (Day)	High Tide (HT)		Low Tide (LT)	
	Time	Height (m)	Time	Height (m)
5/11/2021	10:04AM	3.20	4:56PM	0.09
6/11/2021	10:43AM	3.32	5:38PM	0.10
7/11/2021	11:23AM	3.33	6:21PM	0.21
17/12/2021	8:46AM	2.62	4:00PM	0.54
18/12/2021	9:21AM	2.77	4:36PM	0.50
19/12/2021	9:57AM	2.88	5:10PM	0.51

2.1 Sampling Station

Soil sampling stations were established along the Pantai Punggur coastal route. For the purposes of this test, a total of 20-point locations along the Pantai Punggur coast were designated as Zones A, B, C, D, and E. All zones are classified into four tidal levels: Maximum High Tide (MHT), High Tide (HT), Medium Tide (MT), and Low Tide (LT). The distance between the lowest subsurface and high tide, as well as the unimpeded measuring facilities provided by tree roots, barriers, or roadways, all have an impact on the sampling station selection. Figure 2 depicts the location of the field soil test along the Pantai Punggur coastline.

Fig. 2. Field test stations of Pantai Punggur shoreline

2.2 Field Vane Shear Test (VST)

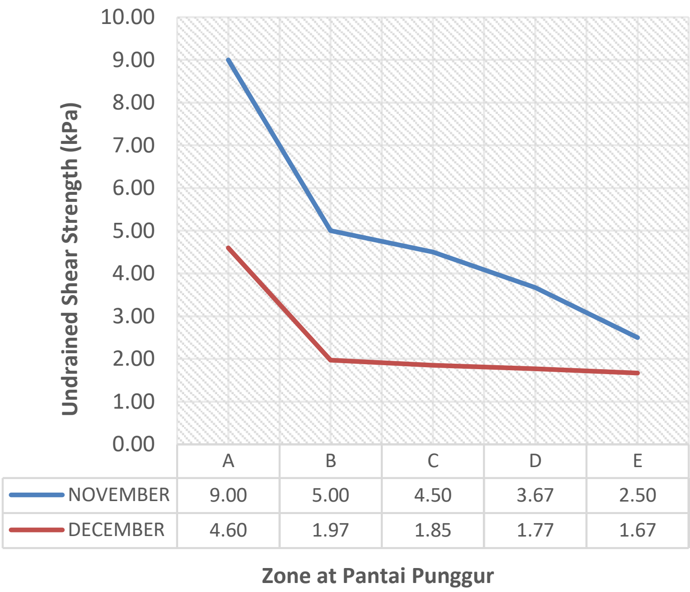
In addition to laboratory methods, field methods are important for studies. This study can also yield quick results and involve the use of tools suited to the soil conditions in the study area. The field vane shear test (VST) (Figure 3) is the best method for collecting data relevant to this study. One of the most significant engineering characteristics of soil is shear strength, and the resilience of soil results from the resistance that failure presents to the movement of soil molecules that are interconnected [18]. The soil's strength can be determined by applying a torsion force to it in order to obtain its torque value, which can be done in the laboratory or in the field using the vane shear test (VST). For this investigation, VST was carried out in the field. One of the most common techniques used for determining soil undrained shear strength is field vane shear testing (VST). The field vane shear test procedure is described in manual [19]. A total of 20-point locations in Pantai Punggur coastal were labelled according to zones such as A, B, C, D, and E for the purposes of this test. VST was performed at each sampling station, and the average shear strength was calculated by evaluating several points on the sample. The vane shear strength of a soil sample ranging from soft to strong cohesive soil was estimated using VST. Because the marine clay soil in this study is soft and has a low cohesive strength, the field VST is the best method for testing its shear strength.

Fig. 3. Field vane shear test (VST) equipment

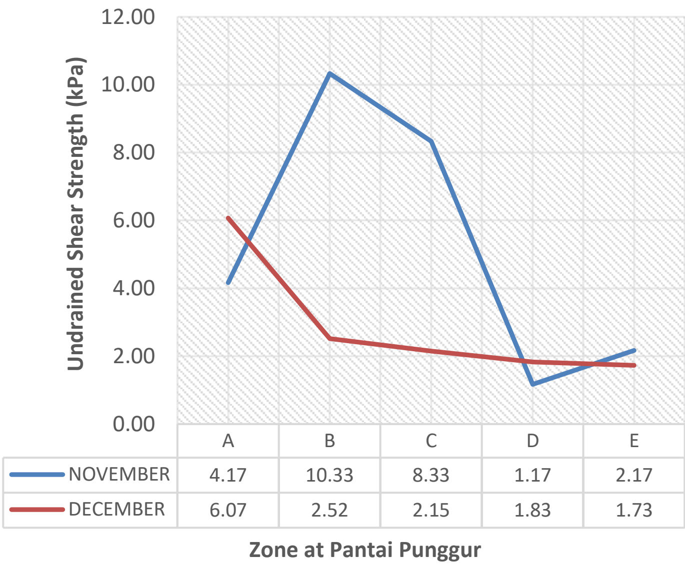
3. Results

According to Figure 2, Zone A, which is located on the left side of the study area, contains natural flora and fauna such as mangrove plants and sandy beaches. Zones B, C, and D are located near the revetment area (Labuan Block) in the centre of the study site. This revetment was built by the Department of Irrigation and Drainage (DID) to prevent coastal erosion in the area. Littoral transport from the mangrove vegetation area was observed in Zone E, on the research area's right side. According to Ref. [20], Zone A is more prone to erosion than the other zones. This data from the sediment analysis indicates that the main component of soil at Pantai Punggur is sand and silt.

Two readings of the field vane shear test (VST) were conducted at various depths, such as 0.5 m and 1.0 m on HT and MT, for every zone in November and December 2021, to obtain the shear strength value. After determining the average value for the vane shear test, all of these values must be multiplied or divided by the value of the blade size ratio used to calculate the undrained shear strength (kPa) [19]. Figure 4 and 5 illustrate the findings of undrained shear strength (kPa) in November and December 2021 for HT and MT, respectively.

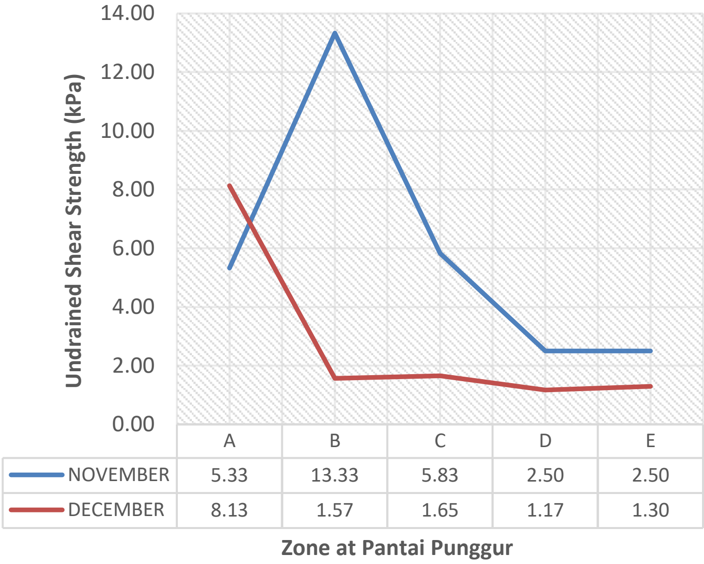


(a)

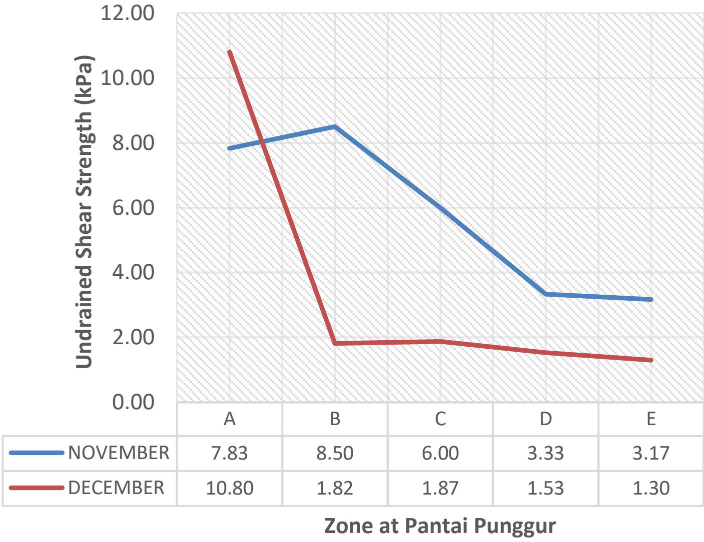


(b)

Fig. 4. High Tide (HT) level depth 0.5 m (above) and 1.0 m (below) graph



(a)



(b)

Fig. 5. Medium Tide (MT) level depth 0.5 m (above) and 1.0 m (below) graph

The comparison values of undrained shear strength (kPa) for HT and MT data for December 2021 at 0.5 m depth are shown in Table 2 and Figure 6. This data is significant because it uses reading data from December 2021 and a depth of 0.5 m to ensure that Cu readings at the HT and MT levels can be measured more accurately. According to the graph, Cu values decrease from HT to MT in all zones except Zone A.

Table 2
The HT and MT data for December 2021 at 0.5 m depth

Zone	The undrained shear strength (kPa)	
	High Tide (HT)	Medium Tide (MT)
A	4.60	8.13
B	1.97	1.57
C	1.85	1.65
D	1.77	1.17
E	1.67	1.30

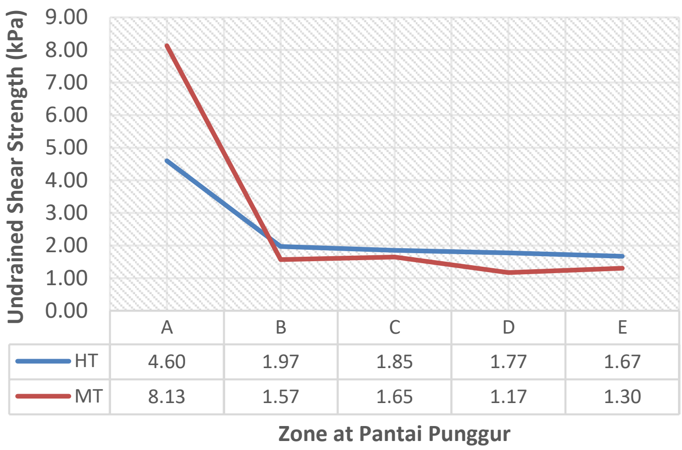


Fig. 6. The comparison of Cu data at HT and MT for December 2021 at 0.5 m depth graph

For both tide levels, Figure 6 shows that the highest Cu is in Zone A, followed by Zones B, C, and D, and the lowest is in Zone E. Cu readings at the HT and MT levels in Zone A exceed 4.5 kPa, while another zone has a reading less than 2.0 kPa. The readings in Zone A also show that the MT is higher than the HT, and the trend of this graph shows that other zones are decreasing. These findings will help to explain additional observations in the HT zone, but at different depths (Table 3 and Figure 7).

Table 3
The depth 0.5 m and 1.0 m data for December 2021 at HT level

Zone	The undrained shear strength (kPa)	
	0.5 m	1.0 m
A	4.60	6.07
B	1.97	2.52
C	1.85	2.15
D	1.77	1.83
E	1.67	1.73

Figure 7 shows the graph for Cu data at the HT level in December 2021. According to the graph, Cu data increases as depth increases. The highest depth level is in Zone A, and the lowest is in Zone E. Cu readings in Zone A at 0.5 and 1.0 m depth exceed 4.5 kPa, while readings in the other zones fall below 3.0 kPa.

The correlation of soil shear strength with shoreline changes in the Pantai Punggur study area is related. In this study, actual Cu at the HT level at 0.5 m depth was used to calculate the undrained shear strength, as shown in Table 4.

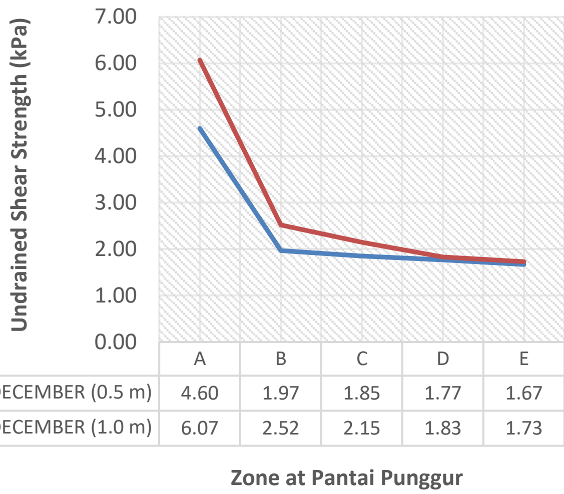


Fig. 7. The comparison of Cu data at 0.5 m and 1.0 m depth for December 2021

Table 4
The undrained shear strength (Cu) value

Zone	High Tide level (depth 0.5 m)		Changes Cu, (kPa)
	November	December	
A	9.00	4.60	- 4.40
B	5.00	1.97	- 3.03
C	4.50	1.85	- 2.65
D	3.67	1.77	- 1.90
E	2.50	1.67	- 0.83

4. Conclusions

The purpose of this study is to determine the undrained shear strength of shoreline areas in Pantai Punggur, Batu Pahat. According to the vane shear test (VST), the results of the undrained shear strength test at 0.5 m depth for HT and MT data for December 2021, Zone A has a Cu reading greater than 4.5 kPa, followed by Zones B, C, and D, and the lowest is Zone E, with an overall value of less than 3.0 kPa. Therefore, from this study, it can be concluded that the depth of a part also influences the data in this study. When the depth increases, the shear strength of the data also increases. The findings obtained from this study provide valuable information in terms of understanding sediment properties that will assist in improving coastal knowledge.

Acknowledgement
This research was supported by Ministry of Higher Education (MOHE) through Fundamental Research. Grant Scheme (FRGS) (FRGS/1/2019/WAB09/UTHM/03/1) and Universiti Tun Hussein on Malaysia (UTHM) through GPPS (Vot Q297).

References
[1] Chalabi, A., H. Mohd-Lokman, I. Mohd-Suffian, K. Karamali, V. Karthigeyan, and M. Masita. "Monitoring shoreline change using Ikonos image and aerial photographs: a case study of Kuala Terengganu area, Malaysia." In *ISPRS Commission VII mid-term symposium "Remote sensing: from pixels to processes", Enschede, The Netherlands*, pp. 8-11. 2006.

[2] Selamat, SITI NORSAKINAH, KHAIRUL NIZAM ABDUL Maulud, FAZLY AMRI Mohd, A. A. A. Rahman, MOHD KHAIRUL Zainal, MUHAMMAD AQIFF ABDUL Wahid, and N. A. Awang. "Multi method analysis for identifying the shoreline erosion during northeast monsoon season." *J. Sustain. Sci. Manag* 14, no. 3 (2019): 43-54.
[3] Sherman, D. J., L. Davis, and S. L. Namikas. "1.13 Sediments and Sediment Transport." (2013): 233-256. https://doi.org/10.1016/B978-0-12-374739-6.00013-0
[4] Nor, Ahmad Hakimi Mat, Saiful Azhar Ahmad Tajudin, Faizal Pakir, Mohd Erwan Sanik, and Salman Salim. "Influence of Biomass Silica Stabilizer on Unconfined Compression Strength of Sodium Silicate Stabilized Soft Clay Soils." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 28, no. 1 (2022): 97-105. https://doi.org/10.37934/araset.28.1.97105
[5] Templin, Tomasz, Dariusz Popielarczyk, and Rafał Kosecki. "Application of low-cost fixed-wing UAV for inland lakes shoreline investigation." *Pure and Applied Geophysics* 175 (2018): 3263-3283. https://doi.org/10.1007/s00024-017-1707-7
[6] Midun, Zamali. *Coastal Erosion: Problems and Solutions*. Persatuan Sains Lautan Malaysia, 1988.
[7] Papakonstantinou, Apostolos, Konstantinos Topouzelis, and Gerasimos Pavlogeorgatos. "Coastline zones identification and 3D coastal mapping using UAV spatial data." *ISPRS International Journal of Geo-Information* 5, no. 6 (2016): 75. https://doi.org/10.3390/ijgi5060075
[8] Burningham, Helene, and Jon French. "Understanding coastal change using shoreline trend analysis supported by cluster-based segmentation." *Geomorphology* 282 (2017): 131-149. https://doi.org/10.1016/j.geomorph.2016.12.029
[9] Petrakis, S., A. Karditsa, G. Alexandrakis, I. Monioudi, and O. Andreadis. "Coastal erosion: causes and examples from Greece." *Proceedings of the Coastal Landscapes, Mining Activities & Preservation of Cultural Heritage, Milos Island, Greece* (2014): 17-20.
[10] Williams, S. Jeffress. "Coastal erosion and land loss around the United States: strategies to manage and protect coastal resources–examples from Louisiana." In *Coastal Ecosystems and Federal Activities Technical Training Symposium Proceedings*. 2001.
[11] Fisher, D. H. "Soil Erosion and Sediment Control in New Jersey," The Standard for Soil Erosion and Sediment Control In New Jersey, (2013): pp. 1-32.
[12] Sparovek, Gerd, and Quirijn de Jong van Lier. "Definition of tolerable soil erosion values." *Revista Brasileira de Ciência do Solo* 21 (1997): 467-471. https://doi.org/10.1590/S0100-06831997000300016
[13] Hussain, Azham, Emmanuel OC Mkpojiogu, Najdawati Mohd Fadzil, and Norhasizasuriati Mohd Hassan. "The UX of amila pregnancy on mobile device." In *AIP Conference Proceedings*, vol. 1891, no. 1. AIP Publishing, 2017. https://doi.org/10.1063/1.5005394
[14] Alsebai, Fouzi, Hooi-Siang Kang, Omar Yaakob, and Muhammad Noor Afiq Witri Muhammad Yazid. "Review of Resources from the Perspective of Wave, Tidal, and Ocean Thermal Energy Conversion." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 30, no. 3 (2023): 127-149. ttps://doi.org/10.37934/araset.30.3.127149
[15] Mokhtar, Mardiha, Fitrah Hayazi, Amy Shahrin Amir Hamzah, Mohamad Shahril Shafiq Isnin, Masiri Kaamin, Mohamad Azim Mohammad Azmi, and Nor Baizura Hamid. "Condition Survey of Eroded Area in Pantai Punggur, Malaysia Shoreline Using UAV Photogrammetry." *Solid State Technology* 63, no. 3 (2020): 826-833.
[16] Hassan, Muhammad Imzan, and Nurul Hanira Rahmat. "The effect of coastline changes to local community's social-economic." *The international archives of the photogrammetry, remote sensing and spatial information sciences* 42 (2016): 25-36. https://doi.org/10.5194/isprs-archives-XLII-4-W1-25-2016
[17] Hassan, Muhammad Imzan, and Nurul Hanira Rahmat. "The effect of coastline changes to local community's social-economic." *The international archives of the photogrammetry, remote sensing and spatial information sciences* 42 (2016): 25-36. https://doi.org/10.5194/isprs-archives-XLII-4-W1-25-2016
[18] Latib, Farah Wahida Mohd, Anuar Kasa, and Mohd Fairuz Bachok. "Geotechnical Properties on Residual Soil of Sedimentary Rock." *Journal of Advanced Research in Applied Sciences and Engineering Technology* 30, no. 3 (2023): 182-191. https://doi.org/10.37934/araset.30.3.182191
[19] America, S. *Instruction Manual*. *International Business*, 1–183, 2003.
[20] Mokhtar, Mardiha, Mohd Effendi Daud, Masiri Kaamin, Muhamad Syamil Sabri, Fitrah Hayazi, Muhammad Hanif Hisham, Mohammad Ikhmal Siddiq, Mohamad Azim Mohammad Azmi, Nor Baizura Hamid, and Hafsa Mohammad Noor. "Beach Profile and Shoreline Sediment Properties at Eroded Area in Batu Pahat." *Construction Technologies and Architecture* 4 (2023): 127-137. https://doi.org/10.4028/p-ny3700