Progress in Engineering Application and Technology Vol. 4 No. 1 (2023) 774–782
© Universiti Tun Hussein Onn Malaysia Publisher's Office

PEAT

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Determination of Seepage Rate Through Senggarang Coastal Embankment

Muhammad Asyraf Azaharrudin[1], Nur Aini Mohd Arish[1], Chan Chee Ming[1], Nor Maizzaty Abdullah[1], Noor Khazanah A Rahman[1], Nur Faezah Yahya[1], Nuramidah Hamidon[1], Tuan Noor Hasanah Tuan Ismail[1]

[1] Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia (UTHM), Higher Education Hub, Pagoh, 84500, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2023.04.01.080
Received 15 January 2023; Accepted 12 February 2023; Available online 12 February 2023

Abstract: In the Malaysian state of Johor, the Senggarang Coastal Embankment is situated in the Batu Pahat area. There is approximately 10 kilometers of coastline, this part of coastline was then divided into 13 points but only two point will be cover in this study are to be analyzed. Senggarang Coastal Embankment has serious seepage and overtopping issues that have damaged the service road, caused flooding on the inland side during high tides, and are likely to fail soon. This could jeopardize stability and increase the risk of the earth bund collapsing. When seepage-related inland flooding occurs, saltwater invasion can result, causing harm to surrounding crops and the loss of productive land. The main research objectives are to determine severe seepage location on Senggarang Coastal Embankment (SCE) and also to monitor and record seepage and compare with tidal effect pattern. Seepage rate was use to calculated the total seepage that flow into the inland by using traditional Piezometer test and Probe Mackintosh. Based on the information that was gathered, the seepage is caused by the tides. At SCE, the Mackintosh Probe has been used to find out how strong the soil is by measuring how many blows it can take before breaking. Probe Mackintosh's results point to a possible place where seepage could leave SCE. Therefore, the result obtained proves that seepage condition at SCE is critical and needed serious provision from responsible party and using compacting soil to increase the value of bearing capacity.

Keywords: Soil Bearing Capacity, Embankment, Seepage, Seepage Rate, Probe Mackintosh

**Corresponding author: nuraini@uthm.edu.my*
2023 UTHM Publisher. All right reserved.

1. Introduction

In the Malaysian state of Johor, the Senggarang Coastal Embankment is situated in the Batu Pahat area. There is approximately 10 kilometers of coastline, this part of coastline is then divided into 13 points but only two out of 13 point will be analyzed (Figure 1.1). Google Earth gave the following coordinates for this place: 1°43'0.02"N to 1°43'1.90"N, 103° 3'1.95"E to 103° 2'58.16"E. The embankment was built between Kampung Segenting and Kampung Sungai Ayam Laut and is roughly 10 kilometers long [1]. Senggarang Coastal Embankment has serious seepage and overtopping issues that have damaged the service road, caused flooding on the inland side during high tides, and are likely to fail soon. This could jeopardise stability and increase the risk of the earth bund collapsing. When seepage-related inland flooding occurs, saltwater invasion can result, causing harm to surrounding crops and the loss of productive land.

Figure 1.1: Study Area

The rate of accretion and the rate of erosion along the shore are both affected by the increasing sea level. An embankment is an artificial mound built from earthy elements like stone and dirt and then compacted [2] to support the raising of a roadway above the level of the existing ground surface in the surrounding area. Unfortunately, as the sea level rises, the embankment's seepage problem will worsen, allowing salt water to flow through it and into the river.

Seepage happens as the water level rises [3]. Consequently, research and a solution are required before the embankment entirely fails and has a negative impact on the surrounding population. The rising water levels of the ocean for a full 12-hour cycle must be analysed. Since seepage is related to the tidal height, this cycle can be used to estimate the rate and duration of this problem. At SCE, the Mackintosh probe has been used to get bearing capacity, which indicated the number of blows that should be applied to the soil in order to assess its strength.

2. Methodology

The methodology flow chart for this investigation was displayed in Figure 2.1.

2.1 Senggarang coastal Embankment

Earthen dams are embankments built of heavily compacted soil or rock fragments [4]. A field assessment revealed that the current embankment had been harmed by coastal tides, which resulted in seepage. Google Earth gave the following coordinates for this place: 1°43'0.02"N to 1°43'1.90"N, 103° 3'1.95"E to 103° 2'58.16"E. In order to prevent flooding, which has become more likely in recent years as the intensity of extreme weather events has increased, embankments are frequently employed along rivers [5]. This is the study's focus region.

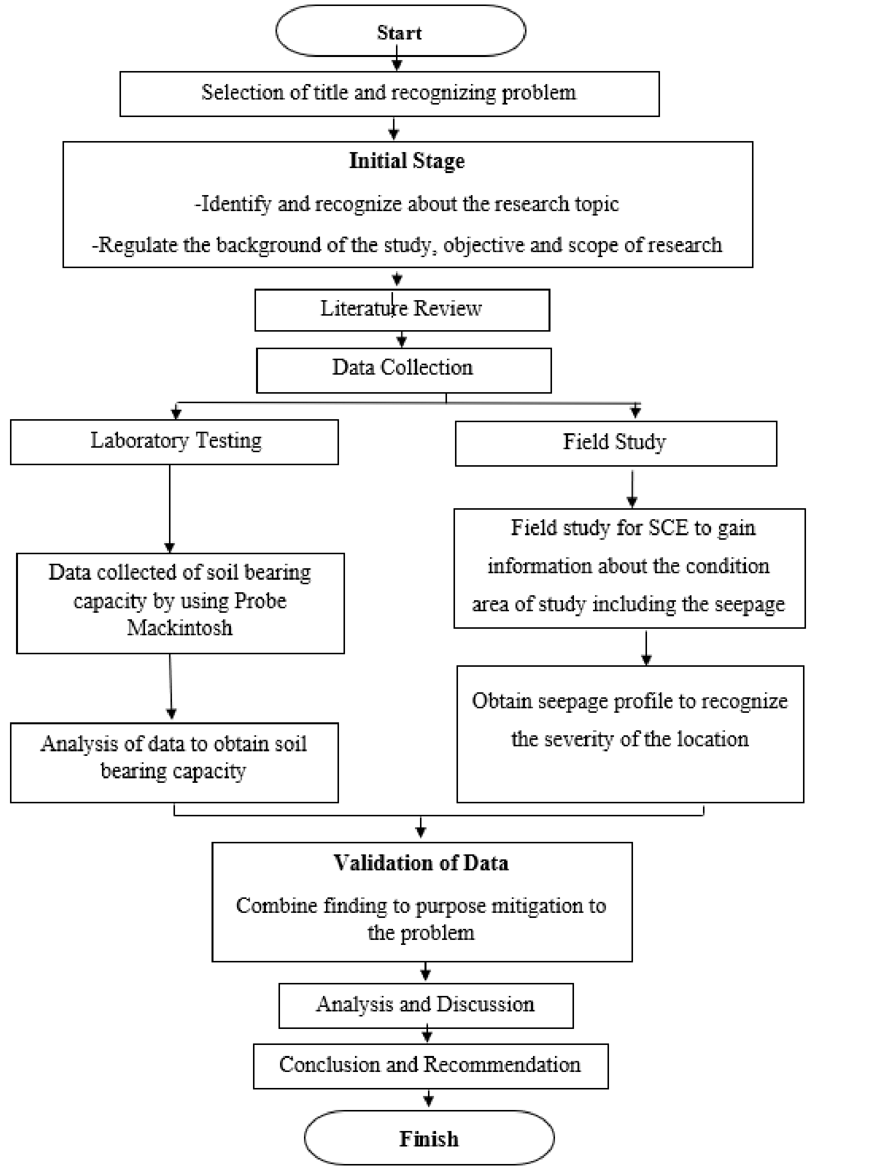

Figure 2.1: Study Flow Chart

2.2 Soil Bearing Capacity

It is a tool that is significantly faster and less expensive than boring equipment, especially when the soils being explored are soft or loose and the exploration depth is moderate. The Mackintosh Probe's capabilities for studying soft deposits are discussed in this research. The reproducibility of test results is examined, and a method for using the Mackintosh Probe is discussed [6]. Results from the Mackintosh Probe and the Standard Penetration Test (SPT), as well as undrained shear strength, are correlated (cu).

2.3 Seepage Analysis at SCE

The movement of water in soils is known as seepage in soil engineering, and it is frequently a serious issue with building foundations [3]. Due to increased excess pore pressure brought on by rising water levels and saturated material, it is possible for water to seep into the body of the embankment.

On November 11 and 12, 2022, a test will be run at SCE to estimate the amount of seepage flow at the greatest monthly tidal level. Piezometer is being used to evaluate a few crucial areas. During the test, the water flow's output is gathered [7]. The reason why this date is chosen is because that day was the high tide will be record base on the tide forecast.

Figure 2.2: 2 Point selected are selected based on the severity of seepage located.

The leak is then made obvious to the unaided eye by adding half-inch PVC pipe to these two spots (figure 3.3). Every 10 minutes, water is collected and recorded because of the 10-minute time period.

Figure 2.3: Severe seepage point current situation on point 1 and point 2.

2.3.1 Calculation

Water collected from the basin are calculated with the formula of:

$$Q = V/T$$

The seepage rate of the collected water is calculated by dividing the volume of water (V) by the 10-minute time interval (T) (Q). While doing the examination, variations in flowrate may be observed. This finding suggests that water velocity and tide height have a significant positive relationship.

3. Results and Discussion

3.1 Probe Mackintosh Result

At SCE Probe Mackintosh has been conducted to obtain bearing capacity to indicated the number of blows in which to determine the strength of the soil [8]. Based on table 3.1, starting at 1.8m to 2.1m the number of blows has reduced and at the same time it is on the same level as the seepage outlet found. For test 1 the number of blows is 72 and this indicated the consistency very stiff. While for test 2, the number of blows was 35 and meaning firm. This conclude that while the top of embankment was strong but both point at 1.8m to 2.1 starting touch stiff or soft soil and slowing seepage will slip through.

Table 3.1 number of blows for Probe Mackintosh in test 1 test 2

Depth (m)	No of Blows (M-Value)		Cumulative No. of Blows	
	Test 1	Test 2	Test 1	Test 1
0.0-0.0	0	0	0	0
0.0-0.3	196	145	196	145
0.3-0.6	94	157	290	302
0.6-0.9	240	350	530	652
0.9-1.2	265	229	795	881
1.2-1.5	67	213	862	1094
1.5-1.8	313	30	1175	1124
1.8-2.1	72	35	1247	1159
2.1-2.4	23	42	1270	1201
2.4-2.7	26	36	1296	1237
2.7-3.0	32	31	1328	1268
3.0-3.3	27	30	1355	1298
3.3-3.6	29	35	1384	1333
3.6-3.9	32	33	1416	1366
3.9-4.2	33	35	1449	1401
4.2-4.5	31	33	1480	1434
4.5-4.8	42	35	1522	1469
4.8-5.1	46	40	1568	1509
5.1-5.4	43	49	1611	1558
5.4-5.7	41	46	1652	1604

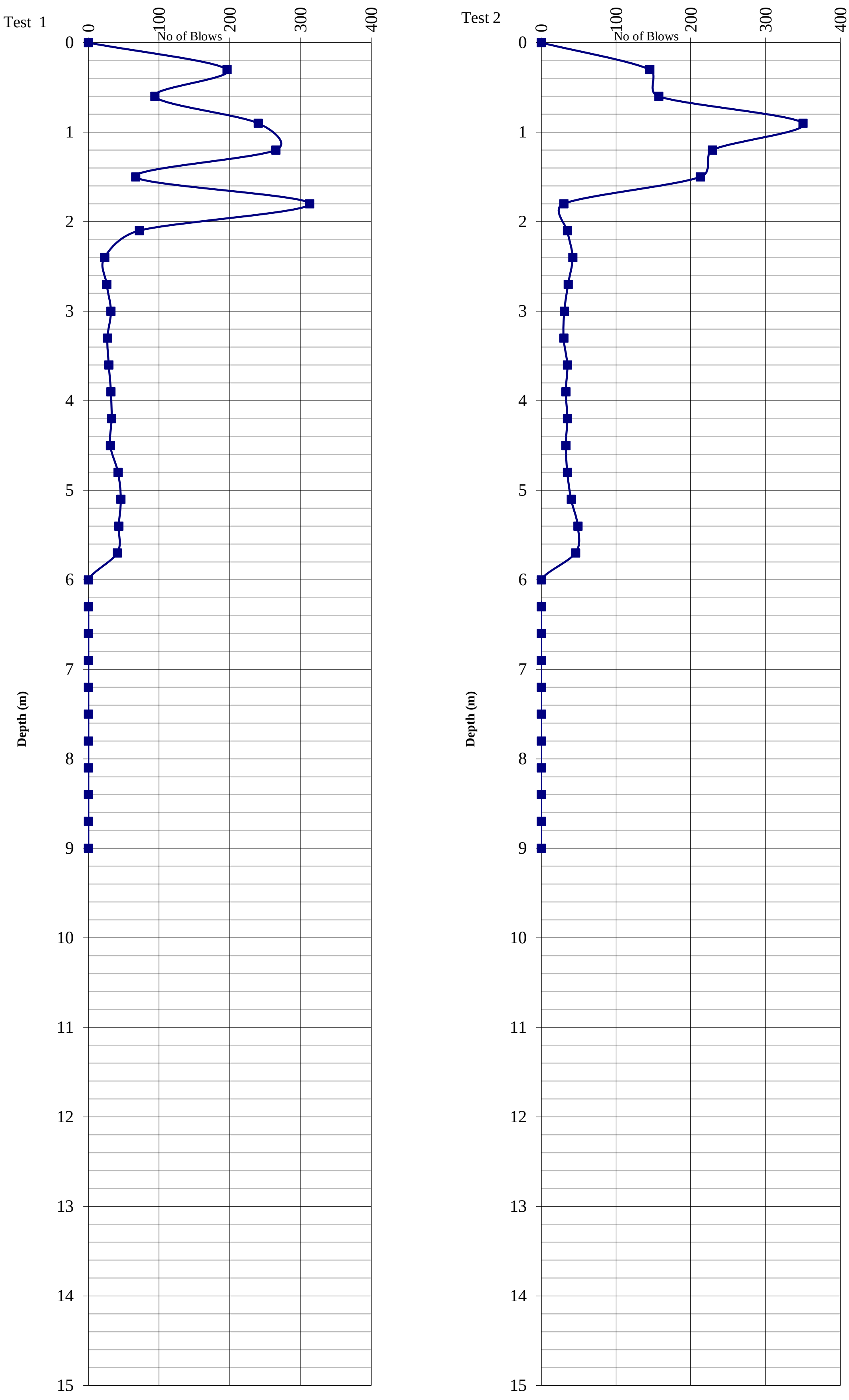

Figure 3.1: Show the number of blows for test 1 and test 2.

According to figure 3.2, the soil is very strong from 0 metres up to 2 metres for both points. The soil begins to loosen up and become low after it is deeper than 2.1 metres and the number of blows has significantly decreased. These findings indicate to a potential discharge point for seepage at SCE [9]. The relationship between Probe Mackintosh and seepage demonstrates that the carrying capacity of the soil determines the discharged point. Both points are obtained below a 2-meter embankment for seepage analysis. This mean, seepage at point 1 and point 2 was aligned because of the out flow of the seepage was around 1m from bottom of the embankment.

3.2 Seepage Analysis Result

On November 11 and 12, 2022, the highest tidal level of the month, SCE will conduct a test to see how much seepage flow there will be. A technology similar to a piezometer is being used to evaluate a few crucial areas. During the test, the water flow's output is gathered. In addition to piezometers and observation wells, certain other common observational techniques also offer useful data on the water level at reading sites and the presence of probable leaks [10]. The volume of seepage and the seepage rate for the SCE seepage analysis are collected.

The SCE tidal height increment is 0.652 cm/min, and seepage doesn't begin until the height reaches 2.1 meters. Tidal height rises from 0.6 m to 3 m in approximately 6 hours, or from 5:37 AM to 11:45 AM. Both points have an estimated 2.1-meter tidal height, and seepage begins at 9:30AM for both of them. The amount of tidal height reduction varies [11], though. With a rate of 0.564 cm/min, seepage stops in around 7 and a half hours.

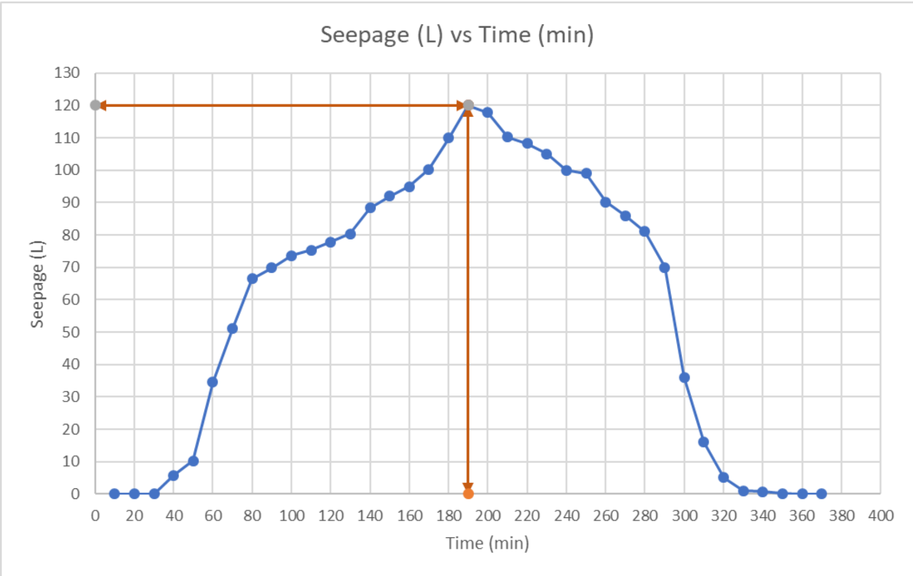

Figure 3.2: Graph seepage rate for point 1

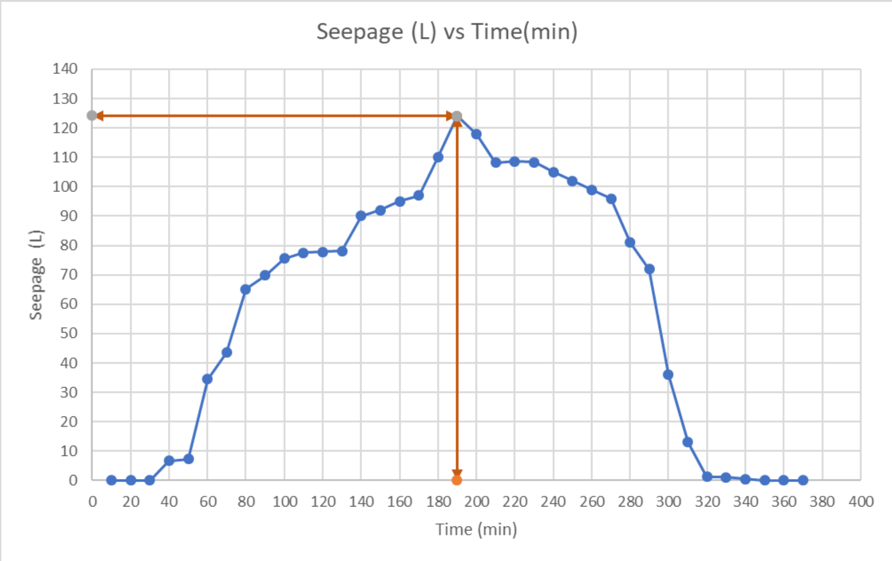

Figure 3.3: Graph seepage rate for point 2

The produced graph demonstrates that the highest readings of volume and seepage rate occur when the tide is at its highest [12]. According to Bakari [13], seepage can cause a slope to collapse by increasing the pressure within the soil pores or by flooding the slope. This rate of seepage is particularly alarming, as it results in massive amounts of runoff that can cause embankment failure.

4. Conclusion

As one of the main objectives of this research project, the seepage at Senggarang Coastal Embankment (SCE) that is generated by tidal action will first and foremost be observed, studied, and documented. In the hopes that it would someday be helpful in fixing the seepage problem at SCE, every bit of information that was gathered is being retrieved. The data support the conclusion that the seepage rate warrants prompt action in order to avert the collapse of the embankment. The majority of the crops at SCE are sterile because the saline water hinders their ability to thrive. The sites with considerable seepage are then detected by keeping an eye on the tide action at SCE. A few important areas have received satisfactory evaluations. However, other places are inaccessible, making it impossible to evaluate them. This is because of how the landscape is. Vertical seepage from the embankment and horizontal seepage from the land are the two types of seepage. We only evaluate vertical seepage fluxes.

Acknowledgement

A special appreciation also goes out to Jabatan Pengairan Dan Saliran (JPS) Batu Pahat for sharing their knowledge about conducting field tests to collect data. The authors further acknowledge the help received from the Faculty of Engineering Technology at Universiti Tun Hussein Onn Malaysia.

References

[1] Lau, L. T. (2022). Seepage Analysis of Senggarang Coastal Embankment with Relation to The Backfill's Compaction Quality

[2] Javadinejad, S., Eslamian, S., Ostad-Ali-Askari, K., Mirramazani, S.M., Zadeh, L.A., Samimi, M. (2018). Embankments. In: Bobrowsky, P., Marker, B. (eds) Encyclopedia of Engineering Geology. Encyclopedia of Earth Sciences Series. Springer, Cham. https://doi.org/10.1007/978-3-319-12127-7_105-1

[3] Huang, S., Lyu, Y., Sha, H., & Xiu, L. (2021). Seismic performance assessment of unsaturated soil slope in different groundwater levels. *Landslides*, *18*(8), 2813–2833. https://doi.org/10.1007/s10346-021-01674-w

[4] Saluja, I. S., Athar, P. M., & Ansari, P. S. A. (2018). Causes of Failure of Earthen Dams and Suggested Remedial Measures, 5(3).

[5] Yang, Y., Chu, J., Xiao, Y., Liu, H., & Cheng, L. (2019). Seepage control in sand using bio slurry. Construction and Building Materials, 212, 342–349. https://doi.org/10.1016/j.conbuildmat.2019.03.313

[6] Fakher, A., Khodaparast, M., & Jones, C. J. F. P. (2006). The use of the Mackintosh Probe for site investigation in soft soils. *Quarterly Journal of Engineering Geology and Hydrogeology*, *39*(2), 189–196. https://doi.org/10.1144/1470-9236-05-039

[7] Roslan, N., Yahya, N. F., Chan, C.-M., Sani, S., & Rosman, M. Z. (2022). Conceptual analysis of seepage control for Senggarang Coastal Embankment with chemically-stabilized backfill. *Maritime Technology and Research*, *4*(4), 258113. https://doi.org/10.33175/mtr.2022.258113

[8] Malik. (2017). Correlation of Electrical Resistivity and Mackintosh Probe - UTP Electronic and Digital Intellectual Asset. *Utp.edu.my*. https://doi.org/http://utpedia.utp.edu.my/id/eprint/778/1/abdul_malik.pdf

[9] Wani Wonga@Wanga, Nazirafazlin, W., Muhammad, & Kassim, N. (2022). Improvement of Portable Mackintosh Probe Extractor. *Multidisciplinary Applied Research and Innovation*, *3*(1), 632–642. https://publisher.uthm.edu.my/periodicals/index.php/mari/article/view/4025

[10] Mousavian, Seyed Mohammad Reza. “Seepage monitoring and diagnosis of distresses in an earth embankment dam using probability methods.” (2017).

[11] Sign in. (2023). Sciencedirect.com. https://www.sciencedirect.com/science/article/abs/pii/S0012825219306877

[12] Numerical investigation on geometric configurations affecting seepage from unlined earthen channels and the comparison with field measurements. (2020). Engineering Applications of Computational Fluid Mechanics. https://www.tandfonline.com/doi/full/10.1080/19942060.2019.1706639

[13] Bakari, D (2020). Numerical Analysis of Senggarang’s Embankment Constructed with Cement-Csp Stabilised Sandy Clay. Univeriti Tun Hussein Onn Malaysia.

[14] Mel, R. A., Viero, D. P., Carniello, L., Defina, A., & D’Alpaos, L. (2021). The first operations of Mo.S.E. system to prevent the flooding of Venice: Insights on the hydrodynamics of a regulated lagoon. Estuarine, Coastal and Shelf Science, 261, 107547. https://doi.org/10.1016/j.ecss.2021.107547

[15] Vesic, Aleksander B. (2023). BEARING CAPACITY OF DEEP FOUNDATIONS IN SAND. *Highway Research Record*, *39*. https://trid.trb.org/view/126654