Director's research and development activities

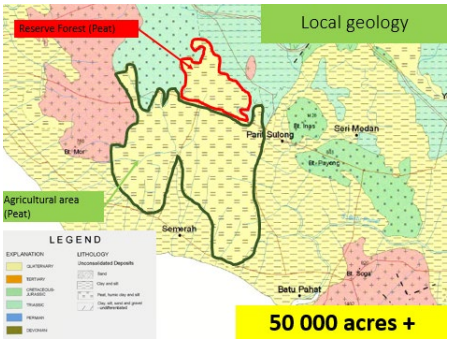
Peat Fire and Muar Living Laboratory Initiative

Nor Azizi Bin Yusoff

Senior Lecturer, Universiti Tun Hussein Onn Malaysia (UTHM)

Early this year, Universiti Tun Hussein Onn, Malaysia (UTHM) reached an agreement with The Muar District in materializing the concept of 'UTHM@Muar Living Laboratory'. In general, a living laboratory is a research concept, defined as user-centered, operating in a territorial context, integrating concurrent research and innovation processes within a public-private-people partnership. Several joint research and innovations had been successfully initiated. In addition, the city had been awarded The ASEAN Clean Tourist City Standard (ACTCS) (2018-2020). Incidences of peat fire at the Ayer Hitam peatland is one of the prime concerns of the city causing significant carbon emissions and economic loss. This short article will highlight some of our latest R&D efforts concerning this initiative.

The 'peat initiative' is the extension of Muar's clean city agenda to create awareness on environmental issues, reduce emissions, and promote sustainable development. The Ayer Hitam, Muar peat land comprises more than 50 000 acres. Apart from this area, the largest virgin peat area in Johore is located at the same place. The total area of this forest is 3797 hectares and it is the last remaining peat swamp forest in the state of Johore. This peatland is a fragile yet unique ecosystem that plays a crucial role in stabilizing the ecosystem, regulating water, soil formation, and most importantly as carbon storage and sequestration. The Ayer Hitam peatland is also home to unique flora and fauna such as the endangered endemic Betta persephone. In response to the city's needs, UTHM established The Regional Peat Fire Research Station for peat fire management.



(a) Peat area at the reserve forest and agricultural area

(b) Forest-village boundary at Ayer Hitam, Muar District

(c) Peat fire issues

(d) Structural integrity issues on peat

Fig. 1. Peatland at Ayer Hitam, Muar and related issues

Based on the engineering perspective, peatland normally triggered several engineering problems such as a peat fire, structural crack, undulating road surface, interruption into a pipeline, high acidic water source, and many more (Fig. 1).

Smoke from burning peat can reduce air quality, particularly within 1km of the fire, as the smoke contains fine particles, water vapor, gases including carbon monoxide, carbon dioxide, and nitrogen oxides. It may also contain sulfur compounds which are odorous. From an economic perspective, peat fire may disrupt the agricultural land, affecting the farmer's revenue, damaging the crops, and incurring additional management costs for the local authority. Several research clusters had been initiated thru the initiatives as listed below.

1. Initial geotechnical and geological survey at Ayer Hitam Utara Reserve Forest, Muar, Johore (Fig. 2)

Our research team is working closely with Johore State Forestry Department, Muar Municipal Council, Muar District Office, and other local partners in protecting the forest. The research team is actively involved in several expeditions and activities. Since 2019, relevant data were collected in order to understand the probability of peat fire at a certain designated area (Maznan Ismon, 2021).

(a) A group of researchers at the peat forest

(b) Visual inspection of peat slope

Fig. 2. Initial geotechnical and geological survey at the peat forest

2. Structural assessment on a building (Fig. 3)

Peat, in its natural state, is considered unsuitable soil for supporting building foundations. It is mainly due to the presence of high organic matter, high moisture content, high compressibility, and low shear strength. In addition, vibration may cause damage or reduce the serviceability of a building (Tuan Norhayati *et al.,* 2021). This study focuses on an existing building in Muar District with the aim of assessing the vibration response of the building and whether the vibration is within the vibration limits as determined by the Department of Environment. A Finite Element Modelling is produced to simulate the building's displacement and deformation under natural frequency and a series of tests consisting of walking test and heel-drop test was performed on-site to obtain the vibration response of the building in terms of acceleration, velocity and frequency (Nursyahirah (2021); Yeoh (2021).

(a) Ultrasonic sounding equipment

(b) Structural health assessment on building

Fig. 3. Structural health assessment at Ayer Hitam, Muar

3. Geotechnical assessment on structure (Fig. 4)

Bridges are essential components of road networks and reflect an important investment in the resources of most countries around the world. This study is initiated in order to determine the condition rating of the bridge structure in Malaysia where it focuses on the bridges in Ayer Hitam, Muar. The aim of this study is to assess the structural condition

of the bridge and describe defects observed in bridge members. The assessment was carried out based on the method practiced by the Road Engineering Association of Malaysia (REAM). The bridge condition rating was presented in assessment form where both quantitative and qualitative methods visualized the performance of this study. The quantitative approach is where bridge parameter data is obtained, while the qualitative method when the data is processed and rated all bridges. In general, the bridge approach was found as the most common defect in most bridges compared to the other components (Ahmed Abdi, 2021).

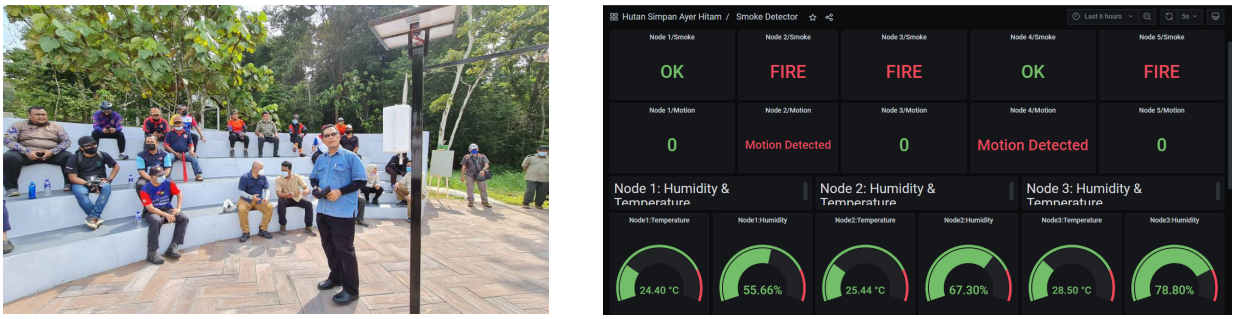
(a) Bridge assessment at Ayer Hitam, Muar

(b) Assessment of a peat settlement

Fig. 4. Structural and visual assessment

4. Development of peat fire monitoring system (Fig. 5)

The prototype kit developed in this research project successfully works to detect smoke, motion, measure temperature, and humidity readings that meet the study's objective in detecting early peat forest fires using automation features equipped in the system. The test results show the presence of smoke and objects under good supervision because it is proven that the prototype kit can send notification messages to the users through Telegram applications. At the same time, data readings from the sensors can be displayed on the GUI in real-time. Moreover, the temperature and humidity readings obtained are accurate, stable, and easy to read. Therefore, the developed system can be used as an early detection tool for peat forest fires (Anuar Hamzah *et al.,* 2021).



(a) Research presentation at the reserve forest

(b) Graphical user interface for the prototype kit using Grafana software

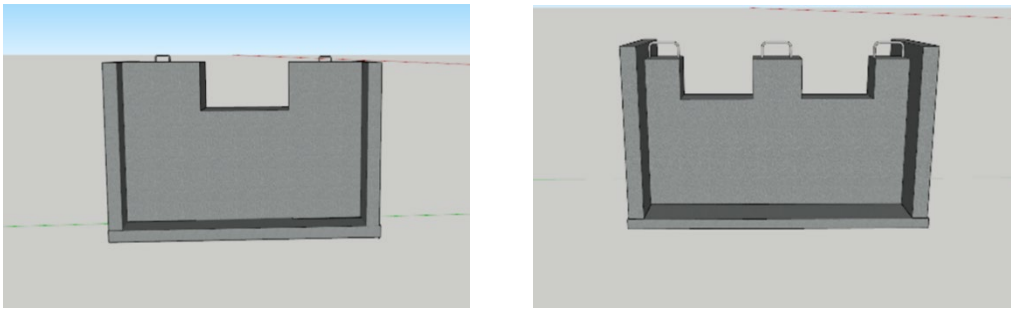
Fig. 5. Peat fire monitoring system

5. Check dam design (Fig. 6)

The most fundamental need for the conservation of degraded peatlands is to restore their hydrological functions and restore a hydrological system that is appropriate/optimal for the restoration of the ecosystem. Optimized (stabilized) water levels are important for the regeneration of peatlands to ensure that the correct conditions are generated for peatlands' ecological role and conservation of peatland biodiversity.

Usually, the use of natural peat will easily block narrower ditches with a depth of up to about 2 meters. Peat with a low water column pressure can also be effectively used for damming large ditches. The peat must be well moisturized in such a way that it is properly waterproof. However, peat dams in 2 m width ditches are likely to collapse on sloping land, and it might be appropriate to use other materials along with peat to block anything above 1 m width.

Based on the requirement of Ayer Hitam peatland, two design options had been proposed for the check dam to suit with the local situation. The first option of the check dam has one rectangular notch in the middle of the check dam while the second design option has two rectangular notches in the middle of the check dam. Both check dam options are made of reinforced concrete. A portable wooden notch could be used to control the water catchment and water flow. It is important to help the villages in the event of emergency and maintenance (Muhammad Faris, 2021).



(a) Check dam (Design 1) (b) Check dam (Design 2)

Fig. 6. Proposed check dam design for Ayer Hitam peatland (Muhammad Faris, 2021).

6. Further research and development work

Further research is in progress in studying the corrosion rate of buried steel piles at Ayer Hitam peatland. The objectives of the research are to analyze the composition of Ayer Hitam Utara peat soil and unburied metal sheet pile using several laboratories and in-situ testing. Later, the performance of metal sheet pile condition before and after embedded in Ayer Hitam peat soil and feasible approach could be drawn to reduce the corrosion effect. In general, the corrosion rate below the water table fluctuation zone decreased significantly as oxygen was depleted. The most critical zone for steel pile corrosion was typically located within the groundwater fluctuation zone. The research may enhance the applicability of steel sheet piles on peat areas. Steel sheet piles may normally be considered in trenches/canals wider than 2 meters where water flow would cease. Preliminary to the sheet piles' construction is important to ensure that the water does not flood beneath the stable earth's piles. In addition, due to the presence of high organic matter, high moisture content, high compressibility, and low shear strength in peat, the Press-in technology could be adopted for future construction. For example, by having a GRB System, Press-in machines utilize reaction force from installed piles integrated with the Earth and carry out piling work while self-moving on top of installed piles. The process will eliminate the need for temporary structure and minimize the biodiversity effect on the reserve forest. Lastly, thank you for the opportunity to share some of my research activities and hopefully, I will be able to update the progress in the future publication.

REFERENCES

Ahmed Abdi Elmi Omar (2021). Visual Inspection of Bridge Condition Assessment. Master of Civil Engineering. Universiti Tun Hussein Onn Malaysia. MSc. Thesis.

Anuar Hamzah, S., Dalimin, M. N., Md Som, M., Talib, R., Utomo, W. M., Ramli, K. N., Abd Jamil, A., Zainal, M. S., Sanusi, M. H., Mustapa, M. S., & Yusoff, N. A. (2021). Design and Built a Prototype Kit for Fire Detection in a Peat Swamp Forest: A Preliminary Results. Journal of Sustainable Natural Resources, 2(1), 7-19.

Maznan Ismon (2021). Infrared Thermography Surveillance Monitoring of Peat Fire at Biotech Reserve Area, Muar. Technical Report.

Muhammad Faris Danial bin Malikhazulkifli (2021). A Study on Check Dam Design at Peat Soil Area for Peat Fire Management. Bachelor of Civil Engineering. Universiti Tun Hussein Onn Malaysia. BSc. Thesis.

Nursyahirah Suhaimy (2021). Crack Assessment on A Residential Building due to Peat Soil Settlement at Ayer Hitam, Muar. Bachelor of Civil Engineering. Universiti Tun Hussein Onn Malaysia. BSc. Thesis.

Tuan Norhayati Tuan Chik, Cheng Sok Rou, Ahmad Fahmy Kamarudin, Seyed Jamalaldin Seyed Hakim, Nor Azizi Yusoff (2021). Vibration Criteria Assessment Due To Piling Works, International Journal of Integrated Engineering, 6, 46.

Yeoh Ying Jun (2021). Structural Health Monitoring (SHM) at Residential House due to Heavy Truck Vibration in Ayer Hitam Muar. Bachelor of Civil Engineering. Universiti Tun Hussein Onn Malaysia. BSc. Thesis.