Composition of particle size at Regency Beach, Port Dickson

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Abstract: In 2015, the coastline in Negeri Sembilan was recorded to have 10.2 km erosion, which is 17.59% of the total 58 km of coastline in the state. Regency Beach, located in Port Dickson, is one of the areas affected by erosion. This preliminary study was conducted to determine the sediment distribution along the coast of Regency Beach. Nine (9) sampling points were identified starting from the lowest water line up to 40 meters inland, over 800 m along the coast. Sedimentary samples were taken in pore strata and analysed to obtain soil characteristics and particle size classification. According to the USCS classification, the sediment in the study area may be considered as moderate sand. Values of uniformity coefficients, Cu and curvature coefficients, Cc show a uniformly uniform distribution with very low moisture content.

1. Introduction
The 8,840 km coastline covering Peninsular Malaysia, Sabah and Sarawak is made up of various geomorphological conditions. Coasts of clay, mud and silt are distributed along the shoreline of west Peninsular Malaysia and Sabah. Sandy coasts are along the shoreline of east Peninsular Malaysia, Sarawak, and parts of west Peninsular Malaysia such as Penang, Port Dickson, and Malacca [1]. The state of Negeri Sembilan is divided into seven (7) districts, which are Seremban, Port Dickson, Tampin, Kuala Pilah, Rembau, Jelebu and Jempol. The state encompasses an area of 665,374.77 hectares and coastline length of 58 km.

The National Coastal Erosion Study in 1985 found that 1,363.6 km of the coastline had eroded. Total erosion increased to 1,400.3 km in 1996 and 1,415.5 km in 2006 including the coast of Negeri Sembilan at 24.5 km. However, the total shoreline erosion in 2015 was decreased to 10.2 km with the increasing of Category 1 erosion of 5.5 km [1]. Table 1 shows the level of erosion experienced by beaches in Negeri Sembilan. Coastal erosion activity usually occurs when sand is washed off the coast by waves while the opposite process begins when sand or other material accumulates on the beach and causes accretion [2]. Meanwhile, Rosnan et al. [3] stated that an indication of erosion or accretion is through the measurement of sedimentary characteristics as it is an important technique in studying sediment movement.
Table 1. Coastal erosion in Negeri Sembilan. [1]

| Year | Shoreline length (km) | Category of erosion | Total shoreline erosion (km) |
|------|-----------------------|---------------------|----------------------------|
|      |                       | Category 1 (km) | Category 2 (km) | Category 3 (km) |                      |
| 1985 | 58                    | 1.1               | 9.6             | 12.9            | 23.6                   |
| 1996 | 58                    | 2.0               | 9.6             | 12.9            | 24.5                   |
| 2006 | 58                    | 3.9               | 7.7             | 12.9            | 24.5                   |
| 2015 | 58                    | 5.5               | 4.5             | 0.2             | 10.2                   |

Coastal erosion is divided into three categories: Category 1 (Critical), Category 2 (Medium) and Category 3 (Acceptable). Table 2 shows three types of erosion categories and their descriptions. What stands out in this table is the variability of erosion. As an example, Category 1 is assigned for a faster-eroding stretch of coastline with a high population density, while a slower-eroding and sparsely populated stretch of coastline will be identified as a Category 3 erosion site [1].

Table 2. Categories of Erosion. [1]

| Categories | Description |
|------------|-------------|
| Category 1 | Critical Erosion: Fast retreating coastline at the rate of more than 4 m/year with generally fairly dense human settlement, with some commercial/industrial activities being served by significant public infrastructure and facilities |
| Category 2 | Significant Erosion: Retreating coastline at the rate of between more than 1 m/year but less than 4 m/year with generally sparsely-populated area, with some agricultural activities being served by relatively minor public infrastructure and facilities |
| Category 3 | Acceptable Erosion: Slowly retreating coastline of less than 1 m/year with generally no human settlement and minimal agricultural activities, and not served by public infrastructure and facilities |

Coastal erosion or sedimentation processes are influenced by beach characteristics including sediment composition, soil water level and vegetation type [4]. Whereas, according to Yang [5], the erosion process also impacts sediment transport and is proportional to the movement of water and sediment particles. The aim and objective of this study was to determine the distribution of sediments in the study area. Hence, a study was carried out to determine sediment distribution in the coastal area of Regency Beach, Port Dickson.

2. Methodology

The Regency Beach is situated along Negeri Sembilan’s coastline at Batu 5, north of Avillion Admiral Cove and about 0.6 km from Port Dickson Marina Bay. Its location is between 2°29’7.63” N, 101°50’43.42” E and 2°28’42.67”N, 101°50’48.62”E with beach length about 800 m [1]. Figure 1 and Figure 2 show location of the study area.
Gopikrishna and Deo [6] stated that the stability of the coastline is protected from threats due to changes in the natural environment caused by the agents of wind, waves, tidal currents, currents, and also due to human intervention. The natural flow of sediment and sediment causing changes in the local sediment budget and thus in the current pattern of accretion or erosion. Based on the previous study of Integrated Shoreline Management Plan (ISMP) Negeri Sembilan from NAHRIM [7], it was reported that this area was categorized as erosion Category 2. However, based on NCES [1], this area had been categorized as erosion Category 1. Figure 3 and Figure 4 show the effects of erosion on the study area. It shows that erosion is still occurring despite the presence of sandbag and retaining walls as a method of erosion control in the area.
2.1. Data Collection
Data collection and information including previous research reports, topographic maps, weather forecasts, wind and daily tidal water levels were obtained from relevant agencies. Weather forecasts and wind speeds are used to ensure weather and sea conditions are ideal for field measurement activities. High tide forecasts give the highest and lowest tides and timescales. Nine (9) sampling points have been identified starting from the lowest water level up to 40 meters inland, over 800 m along the coast. The sampling point was divided into three zones; namely Zone A (at the lowest tide level), Zone B (between the highest tide and lowest tide) and Zone C (at the highest tide level). The collection of 9 sedimentary strata samples aims to determine the distribution of particle size, organic content and moisture along this coastline. The sampling method is based on BS5930:1981[8]. Figure 5 shows a schematic diagram of the sampling points location along the coastline of the study area.
2.2. **Laboratory Analysis**

Laboratory analysis was carried out to determine the characteristics of sediment extracted including Atterberg Limit Test and Particle Size Distribution Test. Atterberg Limit test is performed to determine the moisture content and directly gives the value of Liquid Limit (LL) and Plastic Limit (PL). Liquid limit is the moisture content where the soil flows at its own weight, while the plastic limit shows the average moisture content. 20mm of penetration is used to determine the Liquid Limit (LL). Particle size distribution test is used to determine sample particle size based on BS1377: Part 2: 1990 [9]. The drying size used ranges from 5.00mm to 0.01 mm. Particle size particle data have been used for decades as a tool for analyzing sediment transport processes along the coast, identify sources of sediment, determine the origin and morphology of the beach [10].

3. **Results**

Bird [11], states that analytical data are useful for determining soil types and sediment transport directions. The results of plots are plotted on semi-logarithmic graphs and equation (1) and equation (2) below are used to obtain uniformity coefficients, Cu and curvature coefficients, Cc.

\[
C_u = \frac{D_{60}}{D_{10}} \tag{1}
\]

\[
C_c = \frac{(D_{30})^2}{(D_{60}D_{10})} \tag{2}
\]

where:

- \(D_{10}\) is a particle diameter (mm) that corresponds to 10% transparency
- \(D_{30}\) is a particle diameter (mm) that corresponds to 30% transparency
- \(D_{60}\) is a particle diameter (mm) that corresponds to 60% transparency

\(D_{10}\) is also known as an effective size and can be used to estimate permeability. Grading should be done to determine the size of a particular soil sample distribution. Braja [12] states that larger grading means
that the particle size distribution is larger. The collection of 9 sedimentary strata samples aims to determine the distribution of particle size, organic content and moisture along this coastline. Table 3 shows the descriptive terminology of sediment grain size. According to Braja [12], there are major texture classifications including gravel (> 2 mm), sand (0.1 -2 mm), silt (0.01 -0.1 mm) and clay (<0.01 mm). Table 4 shows the results of the laboratory analysis, while the results of the analysis of plotted drying tests using semi-logarithmic graphs as shown in Figure 6 (i), (ii) and (iii) by zone.

**Table 3. Sediment Grain Size. [13]**

| Descriptive Terminology   | Grain Size | Boundary   |
|---------------------------|------------|------------|
| Very large boulders       | Boulders   | 256-2010 mm|
| Large boulders            |            | 64-256 mm  |
| Medium boulders           |            | 4-64 mm    |
| Small boulders            |            | 0.064-0.06 mm|
| Very coarse pebbles       |            | Sand       |
| Coarse pebbles            |            | 2.4 mm     |
| Medium pebbles            |            | 0.02-0.025 mm|
| Fine pebbles              |            | Silt       |
| Very fine pebbles         |            | 0.004 mm   |
| Very large gravel         |            | Clay       |
| Large gravel              |            |            |
| Medium gravel             |            |            |
| Small gravel              |            |            |
| Very coarse sand          |            |            |
| Coarse sand               |            |            |
| Medium sand               |            |            |
| Fine sand                 |            |            |
| Very fine sand            |            |            |
| Very coarse silt          |            |            |
| Coarse silt               |            |            |
| Medium silt               |            |            |
| Fine silt                 |            |            |
| Very fine silt            |            |            |
| Very coarse silty         |            |            |
| Coarse silty              |            |            |
| Medium silty              |            |            |
| Fine silty                |            |            |
| Very fine silty           |            |            |

**Table 4. Results of uniformity coefficients, Cu and curvature coefficients, Cc.**

| Sample | D10 | D30 | D60 | Cu  | Cc  |
|--------|-----|-----|-----|-----|-----|
| S1     | 0.22| 0.31| 0.40| 1.82| 1.09|
| S2     | 0.20| 0.25| 0.35| 1.75| 0.89|
| S3     | 0.24| 0.30| 0.40| 1.67| 1.00|
| S4     | 0.18| 0.20| 0.25| 1.39| 0.98|
| S5     | 0.021| 0.18| 0.20| 9.52| 7.71|
| S6     | 0.04| 0.19| 0.24| 6.00| 3.76|
| S7     | 0.03| 0.18| 0.21| 7.00| 5.14|
| S8     | 0.021| 0.15| 0.19| 9.05| 5.64|
| S9     | 0.015| 0.04| 0.19| 12.67| 0.56|
Figure 6(i). Particle size distribution in Zone A.

Figure 6(ii). Particle size distribution in Zone B.

Figure 6(iii). Particle size distribution in Zone C.

Braja [12] states that soils with excellent uniformity grading will give a high Cu uniformity value of 15 or more where grains and sand each have values above 4 and 6. While soils with a coefficient of Cc curvature between 1 and 6 and 3 is considered the best grade.
Table 5 shows the analysis of the Atterberg Limit Test using the cone penetration method for every sample at study area while Table 6 shown the optimum moisture content at 20 mm of penetration and mean grain size, $d_{50}$. From the data obtained, it is clear that the value of moisture content in the study area is very low. According to Braja [12] if the moisture content is very low, the soil will act as solid, while if the moisture content is very high, the soil and water can flow like liquid.

### Table 5. Results of Atterberg Limit Test.

| Zone A | Zone B | Zone C |
|--------|--------|--------|
| Penetration (mm) | Moisture Content (%) | Penetration (mm) | Moisture Content (%) | Penetration (mm) | Moisture Content (%) |
| S1 | 26.4 | 2.84 | 23.0 | 0.49 | 35.9 | 0.52 |
| S2 | 22.4 | 3.17 | 18.0 | 1.06 | 29.7 | 0.85 |
| S3 | 21.7 | 3.91 | 17.2 | 1.47 | 22.9 | 1.18 |
| S4 | 19.7 | 5.83 | 15.0 | 2.00 | 16.9 | 1.77 |
| S5 | 16.6 | 10.74 | 16.0 | 2.31 | 15.3 | 2.99 |

| S6 | S7 | S8 |
| 26.0 | 1.47 | 23.2 | 1.46 | 21.7 | 0.83 |
| 23.1 | 2.16 | 19.9 | 2.03 | 18.2 | 1.23 |
| 21.4 | 2.38 | 16.8 | 2.68 | 16.5 | 1.67 |
| 19.7 | 3.16 | 14.1 | 3.23 | 15.4 | 2.08 |
| 16.5 | 3.66 | 12.0 | 4.35 | 13.6 | 3.95 |

| S9 |
| 28.8 | 1.08 |
| 23.2 | 1.12 |
| 21.8 | 1.46 |
| 21.5 | 2.46 |
| 17.4 | 3.14 |

| Sample | Optimum Moisture content, $w$ (%) | Mean grain size, $d_{50}$ |
|--------|-----------------------------------|--------------------------|
| S1     | 5.20                              | 0.38                     |
| S2     | 3.00                              | 0.31                     |
| S3     | 2.58                              | 0.39                     |
| S4     | 0.62                              | 0.25                     |
| S5     | 2.00                              | 0.19                     |
| S6     | 1.54                              | 0.22                     |
| S7     | 1.50                              | 0.20                     |
| S8     | 1.00                              | 0.18                     |
| S9     | 2.02                              | 0.17                     |

### Table 6. Optimum moisture content and mean grain size.

4. Conclusion

In conclusion, the particle size distribution of 800 m on the coast of the study area is classified as sandy sediment. The coefficient of uniformity, $Cu$ range is between 1.39 and 12.67 while the coefficient of curvature, $Cc$ is between 0.56 and 7.71. Therefore, the sediment is classified as a non-uniform distribution based on the Unified Soil Classification System (USCS). The analysis also showed that the
moisture content in the study area was very low which ranged from 0.62% to 5.20%. The results of average particle size, $d_{50}$ range from 0.17 to 0.38 and indicates that it is a medium sand with a mean grain size of 0.3856.

5. References

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