Numerical Simulation for Shoreline Erosion by Using New Formula of Longshore Sediment Transport Rate

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Abstract

In this paper, A new formula of longshore sediment transport rate was developed based on phenomena of fluid movement through the sediment particle. The amount of fluid that penetrates the sediment particles with high permeability more than the sediment particles with low permeability. This formula is applied to identify shoreline erosion around of runway platform of Sultan Mahmud Airport, Kuala Terengganu. The shoreline changes model is solved by using finite difference method. Based on the simulation result by using this method, shoreline profile around this airport occur erosion. This erosion occurs on the south side of this airport. The average erosion in this area during 2 years and 3 years are 24.88m and 33.90m. In addition, the average erosion becomes worst when the simulation was done for 4 years that is equal to 42.93m. It is required an effective coastal management and coastal protection in order to minimize this erosion in the future.

Keywords
Erosion, finite difference method, longshore sediment transport, new formula, permeability

1. Introduction
Today, coastal zone has become an attraction for the human population as they provided many functions such as recreation, trading, transportation, residential and rich marine resource. The increases of human activities in the coastal zone are confronted with coastal hazard. The most significant problem associated with the coast is coastal erosion. Erosion threatens the coastal population and leads to loss of properties along the coastlines. Some examples of coastal erosion caused by human activities such as coastal erosion on the Tangier Harbour caused by breakwater structure (Serdati et al., 2004; Serdati and Anthony, 2007), erosion on the Northeast Bohai Sea (China) with an average retreat rate of 2.6 meters per year during 1986 to 2003 due to dams on the Luan River (Zuo et al, 2009).
Husain et al. (1995) reported that approximately 30% of Malaysia's coastline is experiencing erosion. Terengganu coastline has bad erosion during monsoon season, but the erosion is limited to only certain sections. The greatest erosion was occurring on the north side of the runway platform of Sultan Mahmud Airport Kuala Terengganu. From the visual observation, the offset changes from the original position of the shoreline due to erosion was more than 10 meters during 2010 to 2011 and it is believed that the offset becomes more in 2013 and 2014 (Ahmad et al., 2014). This erosion was caused by coastal construction along Terengganu coastline. The sediment transport in the Terengganu coastline has been disturbed.
Comprehensive coastal zone management and erosion control require a reliable and practical tool for predicting shoreline changes. Mathematical models is an efficient tool to optimize shore protection. Many researchers used mathematical models to predict shoreline change in the coastal engineering project (Miller and Dean, 2004; Hoan, 2006; Reeve, 2006; Zacharioudaki and Reeve, 2008; Avdeev et al., 2009; Kim and Lee, 2009; Walton and Dean, 2011; Davidson et al., 2013; Ahmad et al., 2015; Hidayat et al., 2017). The rapid advance in the field of computer technology is the beginning in the development of numerical models to simulate shoreline change (Stive et al., 2002; Baykal, 2006; Esteves et al., 2009; Hansen and Barnard, 2010; Nam et al., 2011; Walton and Dean, 2011; Davidson et al., 2013; Valsamidis et al., 2013; Hitoshi et al., 2015). The main objective of this study is to identify the shoreline erosion around of Sultan Mahmud airport, Kuala Terengganu by using simulation. The simulation was solved by solving a finite difference method. The numerical simulation is solved by using the new formula of longshore sediment transport that was proposed by Ahmad and Subiyanto (2015). The result of the simulation is shoreline position around of the runway extension Sultan Mahmud Airport, Kuala Terengganu. The result was compared with satellite image to obtain the validation of the simulation. Then, the result was discussed and concluded.

2. Area of Study
The simulation area is approximately 3km changes around of the runway extension Sultan Mahmud Airport, Kuala Terengganu. This area located between $5^0$24’06.67’’N, $103^0$05’55.08’’E and $5^0$22’50.82’’N, $103^0$06’51.13’’E as shown in Figure 1. The coastal area around Sultan Mahmud airport was characterized by the northeast monsoon, with semidiurnal tides and the highest wave occurs during November to March where the average of wave angle is 60-70 degree from the north with the wave high is more than 3m and a tidal range is about 2.04m from mean sea level (Mohamad et.al, 2012).

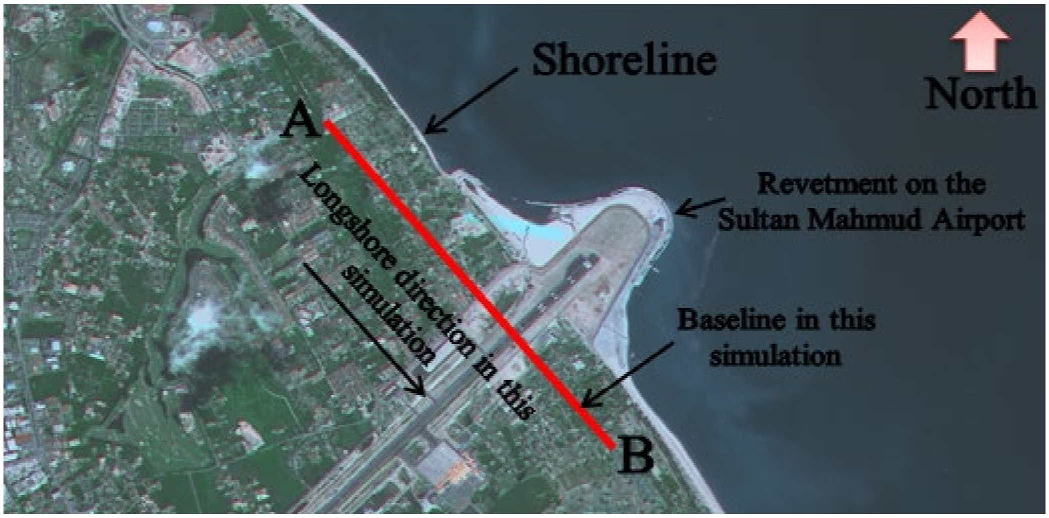

Figure 1. Area of the simulation

The net longshore sediment transports occurred towards the north of peninsular Malaysia (Mohamad et.al, 2012). According to the Mohamad et.al (2012) statement the net of longshore sediment transport will be change due to the expansion of sultan Mahmud Airport. We can assume that the expansion of airport as a coastal structure in this simulation.

3. Methodology

The methodology used in this study based on a numerical method which was introduced by Subiyanto et.al, (2015). This numerical method solves the partial differential equation of shoreline changes model. An approach of finite difference scheme is used to solve numerically the governing equations of shoreline change. This scheme discretizes the shoreline position and longshore sediment transport into a finite grid. The calculation of longshore sediment transport (Q) takes place at the cell wall of each grid cell and the shoreline position (y) is calculated at the middle of each grid cell. The mathematical form of shoreline changes can be written as follows:

$$\frac{\Delta y}{\Delta t} = -\frac{1}{(d)}\left(\frac{\partial Q}{\partial x}\right) \quad (1)$$

where y is the shoreline position (m), x is the longshore coordinate (m), t is the time (s), Q is the longshore sediment transport $(m^3/year)$, and d is the active depth (m) which equal the beach berm height (D_B), plus the closure depth (D_C). The mathematical term of the longshore sediment transport rate in the coastal area can be expressed by an appropriate bulk longshore sediment transport rate formula that relates the movement of sediment to the incident wave conditions (Inman and Bagnold, 1964; USACE, 1984; Kamphuis, 2002).

The new formula of longshore sediment transport rate that used in this study as follows (Ahmad and Subiyanto, 2015; Subiyan to, 2015):

$$Q_{New} = 1.88x10^{-6}\left(\rho_s - \rho\right)\pi\frac{\alpha^2}{C_B}\left(d\right)^2\exp\left(1.31\left(\frac{\ln(d)}{\ln(2)}\right)\right)sgH\frac{\sin(2\theta)}{\mu_0} \quad (2)$$

where Q_{New} is the new longshore sediment transport $(m^3/year)$, ρ is the density of the water (kg/m^3), ρ_s is the density of the sediment (kg/m^3), C_B is a constant friction coefficient that in the general case is dependent on the flow and sediment properties, α is the constant between 0.3 and 0.6 (Longuet-Higgins, 1970), d is geometric mean grain size (mm), s is the local bottom slope, g is acceleration due to gravity (m/s^2), H is the significant wave height at breaking (m) and θ is the wave angle at breaker, μ_0 is the maximum horizontal bottom orbital velocity of the waves at the breaker zone (m/s).

In this study the computation uses a finite difference approach which step backward in the time using intervals of Δt and space using interval Δx with forward discretization. In this study, the numerical model for solving this problem where the angle of incoming wave breaking is not assumed to be small, but it is expanded by using Trigonometric identity (Subiyanto, 2015). It starts from the discretization of the partial differential equation of shoreline position by using backward time approach and the partial differential equation of longshore sediment transport by using the forward space approach. The combination of the partial differential equation of shoreline position and longshore sediment transport discretization has produced a matrix of partial differential coupled. In order to identify shoreline erosion in Sultan Mahmud Airport Kuala Terengganu coastline, this numerical model is applied in this area.

In order to validate the numerical result, the calculation of error estimation was carried out. The error estimation is calculated based on different results between shoreline position from simulation and satellite image. The error estimation is obtained by using equation as follows:

$$S_e = \sqrt{\frac{\sum_{i=1}^{N}\left(\left(y_S\right)_i - \left(y_{IS}\right)_i\right)^2}{N-2}} \quad (3)$$

where N is the number of the shoreline position data points, y_S is shoreline position from simulation and y_{IS} is shoreline position from satellite image.

4. Result and Discussion

The simulation of the shoreline erosion in Sultan Mahmud Airport, Kuala Terengganu coastline is performed in an area of 3 km in the longshore direction is divided into 87 grid points with the width of each grid point is 35 m and 1.4 km in the cross-shore direction (seaward) from baseline. This coastline consisted of very well-sorted sediment with an average grain size is 0.22 mm and slope is 0.005 m . The wave condition is used in these simulations based on field data collected. The average significant wave height ranging from 1.72 m and 2 m/s in group velocity at the breaking point with the obliquely incoming angle 60^0 respect to the shoreline is used in this simulation (Ahmad et al., 2014). All of these values are placed at the offshore boundary in the computation area. This simulation is validated by using image satellite. The numerical validation is shown in Table 1.

Table 1. Numerical result of simulation of the shoreline changes on the northwest of runway extension Sultan Mahmud Airport Kuala Terengganu.

Grid No	Longshore distance (m)	Shoreline position from baseline (m)		
		Satellite image		Simulated 2012
		2010	2012	
1	0	317.128	282.367	277.037
2	34	317.128	282.467	278.283
3	68	317.12	282.61	278.514
4	102	317.111	281.79	277.890
5	136	317.04	282.574	279.694
6	170	315	280.484	278.347
7	204	314.294	277.907	276.255
8	238	315.624	278.095	275.706
9	272	315.655	279.161	276.157
10	306	315.655	279.203	276.784
11	340	315.65	280.256	278.483
12	374	315.652	282.143	279.102
13	408	315.649	284.519	281.426
14	442	314.243	286.922	282.958

15	476	314.241	288.844	285.775
16	510	314.194	289.907	286.642
17	544	300.029	290.018	287.074
18	578	299.982	289.354	286.998
19	612	299.978	288.05	285.362
20	646	292.851	285.9	283.831
21	680	292.844	282.63	280.442
22	714	278.572	278.013	272.926
23	748	275.429	276.66	274.858
24	782	285.712	283.525	267.684
25	816	299.999	301.169	298.130
26	850	385.713	378.298	371.050
27	884	406.237	397.414	405.347
28	918	414.286	411.089	403.516

Based on the calculation of error estimation of the numerical results, it obtained the error estimation of 5.05% for the simulation in the northwest of runway extension Sultan Mahmud Airport, Kuala Terengganu. This value indicates that the shoreline position based on simulation are relatively close to the regression line and the numerical method can be used to identify the shoreline changes nearby Sultan Mahmud Airport, Kuala Terengganu coastline especially erosion in the north of this airport. Later, an investigation of the shoreline change by using the new formula of longshore sediment transport was carried out. The simulation was also conducted on the shoreline changes around of the runway extension Sultan Mahmud Airport, Kuala Terengganu. In order to know the erosion of shoreline position in this area, the simulation was performed during 2 years, 3 years and 4 years. The result these simulations were presented in Figure 2.

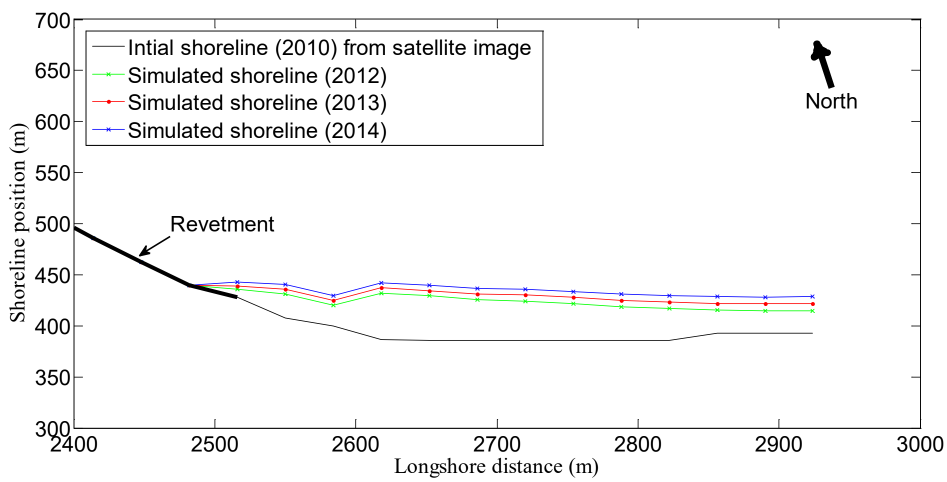

Figure 2. Shoreline changes around the southeast of runway extension Sultan Mahmud Airport Kuala Terengganu.

The numerical result of this simulation was presented in Table 2. This table presents the numerical results during 2 years to 4 years in the area of the northwest of Sultan Mahmud Airport. Based on this table, the average erosion in this area during 2 years and 3 years are 24.88m and 33.90m. In addition, the average erosion becomes worst when the simulation was done for 4 years that is equal to 42.93m. In order to minimize this erosion in the future, it is required an effective coastal management and coastal protection.

Table 2. Numerical result of simulation of the shoreline changes on the northwest of runway extension Sultan Mahmud Airport Kuala Terengganu.

Grid No	Longshore distance (m)	Shoreline position from baseline (m)			
		Satellite image (2010)	Simulated (2012)	Simulated (2013)	Simulated (2014)
1	0	317.128	277.037	262.953	248.870
2	34	317.128	278.283	264.575	250.866
3	68	317.12	278.514	265.181	251.848
4	102	317.111	277.890	264.932	251.974
5	136	317.04	279.694	267.110	254.527
6	170	315	278.347	266.139	253.931
7	204	314.294	276.255	264.422	252.588
8	238	315.624	275.706	264.248	252.789
9	272	315.655	276.157	265.073	253.990
10	306	315.655	276.784	266.076	255.368
11	340	315.65	278.483	268.150	257.817
12	374	315.652	279.102	269.143	259.185
13	408	315.649	281.426	271.842	262.259
14	442	314.243	282.958	273.750	264.542
15	476	314.241	285.775	276.942	268.108
16	510	314.194	286.642	278.184	269.725
17	544	300.029	287.074	278.990	270.907
18	578	299.982	286.998	279.290	271.581
19	612	299.978	285.362	278.028	270.695
20	646	292.851	283.831	276.873	269.915
21	680	292.844	280.442	273.858	267.275
22	714	278.572	272.926	266.718	260.510
23	748	275.429	274.858	269.025	263.191
24	782	285.712	267.684	262.225	256.767
25	816	299.999	298.130	293.047	287.964
26	850	385.713	371.050	366.300	361.550
27	884	406.237	405.347	401.097	396.847
28	918	414.286	403.516	399.516	395.516

5. Conclusion

In this study, the simulation of shorelilne changes by using the new formula of longshore sediment transport was conducted. The simulation was applied on the shoreline changes around of the runway extension Sultan Mahmud Airport, Kuala Terengganu. Based on the validation result, the simulation in the northwest of runway extension Sultan Mahmud Airport produced the error estimation of 5.05%. These error estimation are relatively small, it indicates that numerical result from this study has good agreement the real condition. It can be concluded that the new formula of longshore sediment transport and the new numerical scheme in this study have good capability to solve shoreline changes problem in the reality. In order to know the changing of shoreline position around the runway extension Sultan Mahmud Airport, the simulation was performed by varying time. The time duration is 2 years, 3 years and 4 years. Based on the numerical result, the average erosion during 2 years and 3 years are 24.88m and 33.90m. In addition, the average erosion becomes worst when the simulation was done for 4 years that is equal to 42.93m. These results show that in the future the erosion will affect the coastal communities. Based on these results, it can be considered future steps to prevent this disaster.

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References

Ahmad, M. F., Subiyanto, Mustafa, M., Yaacob, R., Muslim, A. M., and Husain, M. L. (2014). Coastline changes in vicinity of runway platform of Sultan Mahmud Airport, Kuala Terengganu: comparative analysis of one-line model versus satellite data. *Journal of Applied Sciences*, 14(19): 2234-2245.

Ahmad, M. F. and Subiyanto. (2015). A New Formula of The Longshore Sediment Transport Rate for Predicting Long-Term Beach Evolution. ISER- 9th International Conference on Recent Trends in Engineering and Technology. (ICRTET-2015) Istanbul, Turkey.

Ahmad, M. F., Subiyanto and Mustafa, M. (2015). A Long-Term Solution for Shoreline Evolution Induced By Wave Action. *Applied Mathematical Sciences*, 9(88): 4383-4398.

Avdeev, A., Goriounov, E. V., Lavrentiev, M. M. and Spigler, R. (2009). Behaviour-oriented model for long term coastal profile evolution: validation, identification and prediction. *Applied Mathematical Modelling*, 33: 3981-3996.

Baykal, C. (2006). Numerical Modelling of Wave Diffraction in One Dimensional Shoreline Change Model. Master Thesis. Middle East Technical University. Ankara, Turkey.

Davidson, M. A., Splinter, K. D. and Turner, I. L. (2013). A simple equilibrium model for predicting shoreline change. *Coastal Engineering*, 73: 191-202.

Dominic, R. Andrew, C. and Christopher, F. (2012). *Coastal Engineering: processes, theory and design practice (2nd)*. New York: Spon Press.

Douglas, A. L., William, G. M. and Samuel, A. W. (2006). *Basic Statistic for Business and Economics*. New York: Mc Graw Hill.

Esteves, L. S., Williams, J. J. and Lisniowski, M. A. (2009). Measuring and Modelling Longshore Sediment Transport. *Estuarine, Coastal and Shelf Science*, 83: 47-59.

Grijm, W. (1965). Theoretical Form of Shoreline, *Proceeding of 9th Coastal Engineering Conference*, America Society of Civil Engineers: 219-235.

Hidayat, Y., Subiyanto, Ahmad, M.F., Mamat, M., Sambas, A., Supian, S. (2017). Numerical simulation for identifying shoreline erosion in the vicinity of runway platform of Sultan Mahmud Airport, Kuala Terengganu, Malaysia. *Journal of Engineering and Applied Sciences*, 12(18): 4617-4621.

Hitoshi, T., Vo, C. H. and Yuta, M. (2015). Analytical model for concave shoreline induced by the 2011 tsunami. *Procedia Engineering*, 126: 214-217.

Hansen, J. E. and Barnard, P. L. (2010). Sub-weekly to interannual variability of a high-energy shoreline. *Coastal Engineering*, 57, 959-972.

Hoan, L. X. (2006). Some Result of Comparison between Numerical and Analytical Solution of the One-Line Model for Shoreline Change. *Vietnam Journal of Mechanics*, 28(2): 94-102.

Husain, M. L., Yaakob, R. and Saad, S. (1995). Beach erosion variability during Northeast Monsoon. *Pertanika Journal Science and Technology*, 3(2): 337-348.

Inman, D. L. and Bagnold, R. A. (1963). In: Hill, M. N. (Ed.), Littoral Processes, in the Sea, *Interscience*, 3: 529-533.

Kamphuis, J. W. (2002). Alongshore transport of sand. *Proceedings of the 28th International Conference on Coastal Engineering. ASCE*: 2330-2345.

Kim, I. H. and Lee, J. L. (2009). Numerical Modelling of Shoreline due to Structure-Induced Wave Diffraction. *Journal of Coastal Research*, 56: 78-82.

Longuet-Higgins, M. S. (1970). Longshore Currents Generated by Obliquely Incident Sea Waves. *Journal of Geophysical Research*, 75: 6778-6801.

Mehaute, B. L. and Soldate, M. (1978). Mathematical Modelling of Shoreline Evolution. *CERC Miscellaneous Report No 77(10)*. US Amry Corp of Engineering Waterways Experiment Station, CERC.

Miller, J. K. and Dean, R. G. (2004). A Simple New Shoreline Change Model. *Coastal Engineering*, 51: 531-556.

Mohamad, M. F., Omar, N. A. and Huda, M. K. (2012) Physical Modeling Testing for Coastal Infrastructure; A Prerequisite for Marine Engineering. *International Conference on Marine Technology*. Kuala Terengganu: 1-7.
Nam, P. T., Larson, M., Hanson, H. and Hoan L. X. (2011). A numerical model of beach morphological evolution due to waves and currents in the vicinity of coastal structures. *Coastal Engineering*, 58: 863-76.
Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson, C. E. (2007). Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. United Kingdom: Cambridge University Press.
Reeve, D. E. (2006). Explicit expression for beach response to non-stationary forcing near a groyne. *Journal of Waterway, Port, Coastal and Ocean Engineering*, 132: 125-132.
Sedrati, M., Raissouni, A. and El Arrim, A. (2004). Coastal Dynamic and Rehabilitation- Tangier Bay, Northern Morocco case, Proceeding Littoral 2004, Aberdeen, Scotland, U.K. Cambridge University Publication: 721-722.
Sedrati, M. and Anthony, E. J. (2007). A Brief Overview of Plan-Shape Disequilibrium in Embayed Beach: Tangier Bay (Morocco). *Mediterranee*, 108: 125-130.
Stive, M. J. F., Aarninkhof , S. G. J., Hamm, L., Hanson, H., Larson, M., Wijnberg, K. M., Nicholls R. J. and Capobianco, M. (2002). Variability of shore and shoreline evolution. *Coastal Engineering*, 47: 211-235.
Subiyanto, Ahmad, M. F., Mustafa, M. and Husain, M. L. (2013). Comparison of Numerical for Forward and Backward Time Centered Space for Long Term Simulation of Shoreline Evolution, *Applied Mathematical Sciences*, 7(104): 5165-5173.
Subiyanto. (2015). New numerical approach and longshore sediment transport formula for predicting a long term shoreline changes. Ph.D Thesis. Universiti Malaysia Terengganu.
USACE, (1984). Shore Protection Manual. *Department of the Army, U.S. Corps of Engineers*, Washington, DC 20314.
Valsamidis, A., Cai, Y. and Reeve, D. (2013). Modelling beach-structure interaction using a Heaviside technique: application and validation. *Journal of Coastal Research*. 65: 410-415.
Walton, T. L. and Dean, R. G. (2011). Shoreline change at an infinite jetty for wave time series. *Continental Shelf Research*, 31, 1474-1480.
Zacharioudaki, A and Reeve, D. E. (2008). Semi-analytical solutions of shoreline response to time varying wave conditions. *Journal of Waterway, Port, Coastal and Ocean Engineering*, 134: 265-274
Zuo, X., Aiping, F., Ping, Y. and Dongxing, X. (2009). Coastal Erosion Induced by Human Activities: A Northwest Bohai Sea Case Study. *Journal of Coastal Research,* 25(3): 723-733.

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