MINISTRY OF EDUCATION AND TRAINING
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STUDY THE BEACH CHANGES DUE TO EFFECT OF REDUCING WAVE STRUCTURES TO MAKE COMPENSATION FOR HAI HAU - NAM DINH AREAS

Specialization: *Oceanography*
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ABSTRACT OF EARTH SCIENCES DISSERTATION

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INTRODUCTION

1. General justification for the thesis

Along the coast in Vietnam, a lot of protection structures have been built for beaches, sea shore such as: Nam Dinh, Nha Trang, Vung Tau, Tien Giang,... Initially, these structures have also brought some certain efficiencies. However, during the operation, in some places the structures have exposed many weaknesses, inefficient and even corrupt. Therefore, to promote the efficiency of the system structures, studying, calculations and interactive influence of the structures for the hydrological regime of geohydrodynamics near shore must be scrutinized.

From the reasons mentioned above, the thesis *"Study the beach changes due to the effect of reducing wave structures to make compensation for Hai Hau-Nam Dinh areas"* will contribute to addressing the practical requirements of the construction structure of coastal protection in Vietnam. The dissertation chose Hai Hau - Nam Dinh coast as the key area to study.

Hai Hau coast starts from Ha Lan estuary to Lach Giang estuary with 33.32km in length. The whole coast of Hai Hau was eroded over 17.2km in length with the average erosion rate 14.5m/year, the highest erosion rate was 20.5m/year. The process of erosion and destroying dike here was very serious in Damrey storm (2005). Hurricane damage and breakage 8.12km Hai Hau sea dike, with sections broken completely with the length of over 1.0km (Hai Trieu - Hai Hoa).

Therefore, to protect beaches, the sea dike needed to consider and study the geohydrodynamics near shore here. On the basis of some changes the beach, shore rules propose solutions to protect structures.

2. Objectives of the study

1. Initially identified some of rule changes the shoreline, beach to effect of near shore dynamics regimes. Analysis based on measured data for beach-shore change and estuaries volatility affecting regional stability Hai Hau shoreline.

2. Calculated on mathematical models and simulations on physical models to clarify the interaction of wave - structures and the effect of the structures to the morphology shore in the study area.

3. Proposed solution suitable training disaster serves to stabilize study coast.

3. Object and scope of study

- Object study: Effect of sea waves and effect of reducing wave and deposition structures to the beach changes in Hai Hau area.

- Scope of the study: the coastal area of Hai Hau-Nam Dinh.

4. Study methodology: Statistical methods, analyze the document collection, observed document; Experiments on physical models of wave-structures interaction; Mathematical modeling methods.

5. Scientific significance of the dissertation: Contribute to the rationale of the near shore geohydrodynamics, initially identify some of morphology shore changes rules for the specific conditions of the target area study. Building scientific basis to explain the cause of instability in the region coast study.

6. Practical significance of the dissertation: The result of thesis can be applied to the construction, design reducing wave structures, make deposition on beach of actual damages in order to improve economic, technical efficiency. This is also a useful reference document for technical staff working in consulting, design of coastal buildings. Research problems of a completely new thesis, was first studied in Vietnam.

7. New academic contributions of the dissertation:

- Initially identified some of rules of beach changes, built relationships between beach changes by wave action and nearshore currents of typical beach profiles for the study area. Identify the causes of developments shore, beach in the study area.

- Based on simulation results of (physical model and mathematical model) the interaction between the waves and the structuresthe effect of the structures on morphology was identified, then the appropriate training structures for the study area was selected.

8. Structure of the thesis: In addition to the Introduction, Conclusions-recommendation and references, the structure of the thesis consists of 4 chapters: **Chapter 1**- Overview of the research in the world and Vietnam; **Chapter 2**- Choice and setting the study methodology; **Chapter 3**- The causes and characteristics of coast, beach change and beach profile in Hai Hau areas; **Chapter 4**- Results of experiments on physical models and numerical simulations of the technical parameters of submerge dikes protecting the shore and morphological changes in Hai Hau.

CHAPTER 1. OVERVIEW OF RESEARCH IN THE WORLD AND VIETNAM

1.1. Studying in the world

Studies on shoreline, beaches changes flourished from about the 70 - 80 year of the 20th century.

- Bakker (1968) presents an overview of the beach profiles to 2 depth contour representation and assumes that the value of sediment transport cross shore proportional to the deviation of beach slope from an equilibrium. Then expand the study by Kriebel & Dean (1985), Larson & Kraus (1989), Kraus (1991) [61], [70], [80].

- Based on the measurements, then by experience to analyze, evaluate bottom changes occurred after the construction of port facilities in Japan, then made diagrams that represent studies Tanaka's research (see [23]) and scientists in Japan.

- Many studies have been edited, published as books: Richard Soulsby [52] in 1997 with the book *"Dynamics of marine sands"*, presented the actors, mechanisms and methods of transport research and downs integrated, deposition-erosion. Krystian W. Pilarczyk and Ryszard B. Zeidler (1996) [80] with *"Offshore breakwaters and shore evolution control"*, presented the process of evolution of the shore due to effect of detach breakwater with many solutions, recommendations and accompanying guidelines. In 2002, B. Mutlu Sumer and Jorgen Fredsoe [62] published *"The mechanics of scour in the marine environment"*, referring to the mechanics of erosion, erosion patterns around the building,...

- *Studies on the mathematical model may include:*

+ Bakker (1968, 1970), giving the simulation model changes beach around a groin or a group of structures [65], [67]. Later Hulsbergen (1976) extended the study [69].

+ Madsen and Grant (1976) provides simulation models when volatile bottom building a breakwater parallel to the coast. Similarly, Perlin (1979, 1987) provides simulation models for change in the area behind the bottom of reducing wave structures [61], [69], [80].

+ Winter (1993) applied the basic process of beach profile model with breakwater placement [69], [72].

+ Hanson (1987) gave GENESIS simulation model change long coastline over time [10], [80].

- *Studies on the physical models may include:*

+ In 1972, J. W Kamphis, MJ Paul and A. Brebner (Delft Institute) conducted experiments with the theme *"Likewise the beach profiles balance"*. The author P. S Eagleson, B. and J. A Dracup Gulene also similar experiments [66], [79].

+ In 1983, Khomicki [80] tested a range of the evolution shoreline, beaches in the area of offshore breakwater and provide empirical formula and accompanying recommendations.

+ In 1992, Dean-Rosati [64], [82] has conducted 250 scenarios with 4 offshore breakwater to assess the affect of building parameters to the evolution of the shore, beach.

+ Horikawa (see [23]) have conducted experiments to study the criteria for the shoreline forward or backward. The problem: erosion/deposition before groins, erosion around the breakwater head,... have been Japanese scientists experiment (see [23]), [69].

- Some authors have focusedresearch for T groins: Frech (1949), Ishihara &Sawaragi (1968), Sato & Tanata (1974),... the authors have evaluated the effectiveness of T groins [64], [70], (see [83], [85]).

1.2. Studying in Vietnam

Studies in Vietnam may include representative works:

- Vietnam Academy for Water Resources with some basic investigation projects conducted synchronously measuring topography, hydrological, sediment to analyze developments in the key beach choice [40], [41], [45].

- The study results have been published in magazines, reports, conferences... as the author:

+ Vu Thanh Ca, Nguyen Quoc Trinh (2007) published the theme *"Research on the causes of coastal erosion inNam Dinh"*. Study results based on the model wave propagation in near shore areas and sediment transport along the beach of Nam Dinh [7].

+ Nguyen Tho Sao et al (2010) with the theme *"Assessing the effect of structures to hydrodynamic in Ben Hai, Quang Tri coastal-estuary"* The authors applied model Mike 21 to study effect assessment of the project to the field of hydrodynamic in Tung estuary [53].

+ Nguyen Manh Hung (2010) with *"Evolutions coast and estuaries Vietnam"* is the book refers to the process evolution coast, estuary, which refers to the coastal area of Hai Hau [14], [24].

+ Nguyen Manh Hung et al (2011) with the theme *"Calculating volatility coast in Hai Hau-Nam Dinh areas and the Red River Delta by simultaneous effect of wave and tide"* has used the model: wave (SWAN, STWAVE); current (ADCIRC, CMS-M2D); change bottom (LUND-CIRP). Calculating beach change for Red River deltas areas by seasonal, year [14], [25].

Thorsten Albers and N.V Lieberman and colleagues in Vietnam (2011) with the theme *"Research on current and erosion model"*, used the wave model (SWAN), hydrodynamic model (RMA*Kalypso), deposition-erosion model (RMA, GENESIS) for research in Vinh Tan, Soc Trang marine areas [12].

- The Key Laboratory of River and Coastal Engineering is a base on which most of the themes of training of rivers and coasts in Vietnam based on physical modeling studies. However, the main focus is still on the process of wave propagation, wave action on sea dikes, the reduce wave through mangroves,... Little research experiments on the beach morphology due effect of structures.

- Studies use physical model that Thorsten Albers and N.V Lieberman and Vietnam colleagues [12] in 2011, had experiments to study erosion-deposition the surrounding buildings. The plan proposed traning structures suitable for Vinh Tan, Soc Trang area.

1.3. Conclusion for Chapter 1

Until now the study of geohydrodynamics, morphological changes have been inherited and promoted, equipment and technology to modem for research. However, so far no one model that can accurately predict erosion, deposition, erosion-deposition structure around. Other, to ensure the similarity in physical models still faced to many difficulties.

In Vietnam, the study of near shore training structures recently made rapid progress, some structures have shown effectiveness. But, many structures were built for no highly effective, even damaged. For Hai Hau areas still exist the following problems: So far no solution has been proposed to remedy erosion Hai Hau beach; Most previous research has not brought a solid scientific basis for the mechanism and cause beach fluctuations, Hai Hau coast; Research suggest appropriate political solutions to the coast of Hai Hau is an urgent need.

CHAPTER 2. CHOICE AND SETTING THE STUDY METHODOLOGY

2.1. Choice the study methods

The thesis used three main methods: Surveys and statistical analysis of data collected as basis to make conclusions, serve many purposes; Choice the wave flume system Flanders trough of Vietnam Academy for Water Resources to conduct experiments to determine the recommended reduction wave of underground dike (coefficient K_t); GENESIS application model to calculate the effect of building parameters to the shoreline changes. Applying the FM Mike 21 model to calculate the beach changes when the training structures.

Each study method has its own strength and resolve specific problems. However, among them there are links, complement each other to address common objectives of the thesis.

2.2. Survey methodology and statistical analysis of the data collected

2.2.1. Survey methodology, analysis of measurements: This method is quite long and important to this day.

2.2.2. The data collected, analysis of the thesis: (1)- Documents of geology, geomorphology in study area; (2)- Documents of climate, meteorology; (3)- Documents of hydrological, sediment.

2.2.3. The contents of the statistical analysis of data collected, the measurement of the thesis: Analysis to choose the input for study, calculations and modeling; Define the rules to beach change and making characteristics equation beach profile; Analysis found the cause destabilizing coast to base training solution proposed.

2.3. Study methods on physical models

2.3.1. The theoretical basis for experiment wave modeling

- The issues distorted and undistorted: To obtain similar dynamics and morphology-dynamics, wave models are often designed according to the undistorted model and rate model constants $\lambda_l \leq 60$. When forced to distort and coefficient $\eta = \lambda_l / \lambda_h \approx 2$ [20], [82], [86].

- Similar Constant: Rate constant wave length and wave height should be the same, a similar law compliance Froude [20].

2.3.2. Similar simulation values, choice ratio model: Choice the undistorted model, choice rate $\lambda_L = \lambda_h = a = 20$ [20], (see [86]).

Table 2.1. The rate value model - undistort

The quantity	Rate model/ undistorted	The actual value in the study area (ratio 1/20)
Wave length, wave height (m)	$\lambda_L = \lambda_h = a$	20

The quantity	Rate model/ undistorted	The actual value in the study area (ratio 1/20)
Time, wave period (s)	$\lambda_T = \sqrt{\lambda_L} = \sqrt{a}$	4.472
Frequency (Hz)	$\lambda_f = \frac{1}{\lambda_T} = \frac{1}{\sqrt{a}}$	0.2236
Weight (kg)	$\lambda_P = \lambda_L^3 = a^3$	8000
Area (m^2)	$\lambda_s = \lambda_L^2 = a^2$	400
Volume (m^3)	$\lambda_P = \lambda_L^3 = a^3$	8000
Unit pressure (mBar)	$\lambda_p = a$	20
Discharge (m^3/s)	$\lambda_q = \lambda_L^{2.5} = a^{25}$	1788.854
Speed	$\lambda_v = \sqrt{\eta_L} = \sqrt{a}$	4.472

2.3.3. Introduction about the wave flume system Flanders

- Wave flume and wave generator: Wave flume length 40.0m, 2.0m wide, 1.8m high. Piston type of wave generators, can generate regular waves (Sine), not regular waves with spectrum type: Pierson Moskowitz, JONSWAP, can create H_s=1.5 cm ÷ 30.0cm, T_s=0.5s÷5.0s on model.

- Equipment for data collection-Model Golf-3B wave sensor: small size, wide frequency range (1200 mm), fast response (55 ms).

- Connect the system: The entire system is interconnected and controlled automatically by the dedicated software.

2.3.4. The boundary conditions of topography data, hydrological:

- Topography data: The profile of the dike - beach in Hai Hau actual measurements.

- The waves and water levelsparameters used in the experiments:

a) The water level used: As shown in Table 2.2.

Table 2.2. Aggregate water level used in the experiments

No	Case	Undistorted			Model (Scale: 1/20)		
		$WL_{5\%}$ (m)	*Surges (m)*	*WL total (m)*	*$WL_{5\%}$ (m)*	*Surges (m)*	*WL total (m)*
1	Low tide	-	-	1,20	-	-	0,060
2	Mean tide	-	-	1,86	-	-	0,093
3	Level 8	2,20	0,42	2,62	0,110	0,021	0,131

No	Case	Undistorted			Model (Scale: 1/20)		
		$WL_{5\%}$ (m)	*Surges (m)*	*WL total (m)*	*$WL_{5\%}$ (m)*	*Surges (m)*	*WL total (m)*
4	Level 9	2,20	0,80	3,00	0,110	0,040	0,150
5	Level 10	2,20	1,30	3,50	0,110	0,065	0,175
6	Level 11	2,20	1,47	3,67	0,110	0,074	0,184
7	Level 12	2,20	1,80	4,00	0,110	0,090	0,200

b) Wave levels: the wave height from 0.70m ÷ 2.70m, corresponding wave period from 4.0s ÷ 10.0s (Table 2.3), Jonhswap spectrum wave.

Table 2.3. The wave parameters included in the experimental

Undistort		Model (Scale: 1/20)	
Height H (m)	*Period T (s)*	*Height H (m)*	*Period T (s)*
0.75 ÷ 2.70	4.0 ÷ 10.0	0.038 ÷ 0.135	0.894 ÷ 2.236

2.3.5. Calibration of the physic model

- Correction, calibration wave sensor: Use wet methods of calibration [68] to calibrate the linearity allows.

- Calibration the input wave: wave measured at the W_1 is compared with the actual measured wave in HaiHau (Figure 2.1a, b).

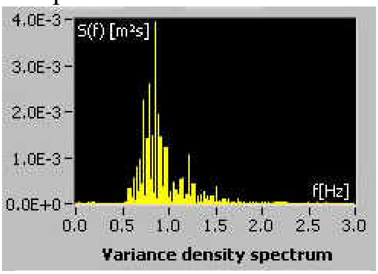


Figure 2.1a. Wave spectrum put on calibration

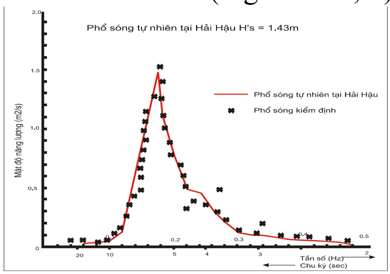


Figure 2.1b. The calibration results in Hai Hau wave spectrum

2.3.6. The experimental plan: Experiments to choice the parameters: Elevation crest of groundwater dike (Δ); Crest width (B); Slope (m). The scenario conducted with combinations of water levels and wave.

2.4. Study methods on mathematical models

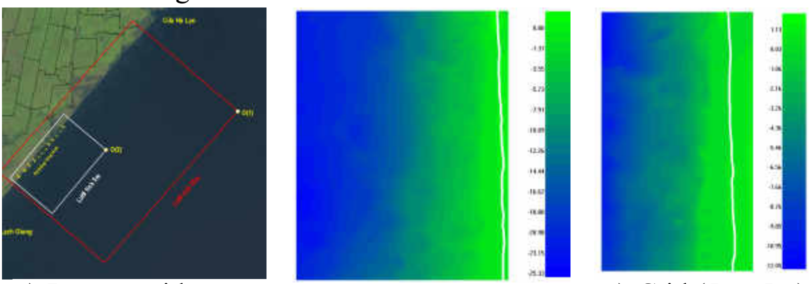
2.4.1. Introduction about shoreline evolution GENESIS model: The basic assumption of Genesis: (1)-Beach profile when toward land or sea unchanged; (2)- Movement limit of beach profile must be clearly defined; (3)- Only calculated longshore sediment transport, excluding transportation cross shore; (4)- Applied to calculate the long-term scale [10], [57].

2.4.2. Introduction about MIKE 21FM model: Use conjugate 3 modules: Wave (Mike21SW), Current (Mike21HD) and Sediment transport (Mike21ST) calculation [74], [75], [76], [77].

2.4.3. Set shoreline changes models and the plan calculation

1. Set the scope and grid calculation: Use square mesh with two different domain, large grid (50m x 50m) to calculate the entire coast of HaiHau. Small Grid (5m x 5m) for detailed calculation for layout structure area (Figure 2.2).

2. Correction and calibration models: The correction factor is determined: K_1 = 0.56; K_2 = 0.45, parametric sediment: D_{50} = 0.14mm. Calibration calculate and compare with the trend of shoreline change from 1985-1995 in Hai Hau for relevant results.



a) Layout grid b) Grid (50m x 50m) c) Grid (5mx5m)

Figure 2.2. Layout and Genesis grid calculated for Hai Hau area

3. Conditions input for models calculation: Applied for two calculation grids, with the natural beach and the structures, including:

- Wave data are derived from Bach Long Vi and Con Co by MIKE 21 model, then extracted at two boundaries of both large and small mesh to calculate the input wave.

+ Waves to calculate calibration are repeated from 1985 to 1995;

+ Waves calculations predict changes in Hai Hau shoreline are repeated from 2009 to 2020;

+ Waves calculate shoreline changes when the structure was repetitive in 5 years (2012-2017) and 10 years (2012-2022).

- Water level fixed with mean values: H_{TB} = + 1.86m.

- The parameters of sediment: D_{50} = 0.14mm.

- The value of the coefficient of reduction wave (Kt) is taken from the results of physical model corresponding water level.

4. The plan calculations in thesis:

- *Forecast of the shoreline change in natural conditions.*

- *Calculation of the parameter choice structures:* Effect of length (L), the distance to shore (X) and width between the gaps (G) of submerge dikes to morphology in turn calculated with the scenarios as follows: L = 50 ÷ 200m; X = 50 ÷ 200 m; G = 25 ÷ 150m.

- Calculate the plan proposed training structures.

2.4.4. Set modeling calculation of geo-hydrodynamics (Mike 21) and the plan calculation of the thesis

1. Set the grid and scope calculations: large grid covering the area from Bach Long Vi to Con Co (Figure 2.3a) to calculate wave propagation in Nam Dinh area, then extract in boundary of mall mesh to input for scenarios calculated. Small mesh dividing detail for calculations in Hai Hau, Nam Dinh area (Figure 2.3b).

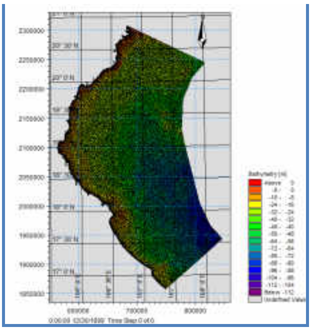


Figure 2.3a. Large grid domain

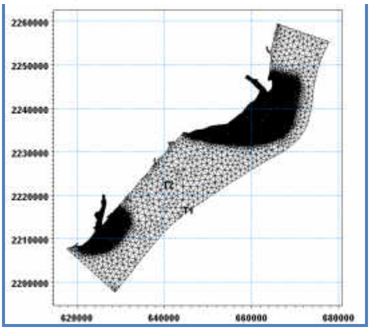


Figure 2.3b. Small grid domain

2. Correction and calibration models:

- *Calibration of dynamic factors:* Using standard Nash (Nash and Sutcliffe 1970) to evaluate, table 2.4.

- *Calibration of sediment transport:* Based on beach profile measuring in Hai Hau (2005-2010), the results showed that the suitable for between the calculated and measured in both the Northeast and Southwest monsoon.

Table 2.4. Evaluate to the error follow standard Nash

TT	The parameters evaluated	Nash index
I	***Large grid domain***	
1	Wave height	-0,07
2	Wave direction	-0,66
II	***Small grid domain***	
1	Water level in Ba Lat estuary	0,84
2	Water levels in Lach Giang estuary	0,91
3	Wave height	0,06
4	Wave direction	-0,47
5	Nearshore Velocity	-0,58
6	Nearshore Curent direction	-1,07

3. Boundary conditions water level, wave and sediment:

- Application of symmetric boundary conditions in the northern and southern boundaries. At the offshore boundary, calculate to 22 plan (PA) as in Table 2.5.
- Waves of storms calculated with Damrey storm (9/2005) [18].
- Water levels calculated with the mean tide (H_{TB} = 1.86m).
- Sand diameter: D_{50} = 0.14mm; Selectivity of sand: σ = 1.4.

Table 2.5. The wave plan to take into calculations

PA	Wave height-Hs (m)	Wave period-Ts (s)	Wave direction θ (^{0})	PA	Wave height-Hs (m)	Wave period-Ts (s)	Wave direction θ (^{0})
1	0,76	3,7	45	**12**	1,51	5,7	90
2	1,19	3,7	45	**13**	1,62	5,7	90
3	1,45	5,7	45	**14**	2,30	5,7	90
4	1,77	5,7	45	**15**	8,83	12,3	90
5	2,35	5,7	45	**16**	1,13	3,1	113
6	3,36	5,7	45	**17**	1,48	5,6	113
7	7,37	11,4	45	**18**	1,76	5,6	113
8	1,22	3,1	68	**19**	2,98	5,6	113
9	1,42	5,6	68	**20**	1,16	3,2	135

PA	Wave height-Hs (m)	Wave period-Ts (s)	Wave direction θ (^{0})	PA	Wave height-Hs (m)	Wave period-Ts (s)	Wave direction θ (^{0})
10	1,83	5,6	68	**21**	1,43	5,7	135
11	1,20	3,0	90	**22**	1,91	5,7	135

4. The plan calculations in thesis:

- Calculation of the dynamics changes and sediment transport in conditions of natural beach with 22 plans (Table 2.5).

- Calculate the plan proposed training structures including 07 T groins, combine 05 submerge dike with 22 plans above.

2.5. Conclusion for Chapter 2

Applied 3 main study methods: Statistics and analyzes the survey data, collected; Experiment on physical modeling and simulation on mathematical model. Statistical, analytical measurements, collect will find some rule changes and cause instability shore - beach in Hai Hau. Experiments to determine the parameters of structures: crest elevation, crest width, slope. Mathematical model to simulate the effect of parameters structures to the shoreline changes and assess the effectiveness of the proposed training structures.

Chapter 3-CAUSES AND CHARACTERISTICS OF CHANGE COAST, BEACH PROFILE IN HAI HAU AREAS

3.1. Morphology estuaries affect stability of the shoreline in Hai Hau

3.1.1. Evolutions Ba Lat, So, Lach Giang estuaries and their effect to stabilize the shore, beach Hai Hau

- So river and deposition activities of the Ha Lan esturay in recent history: About 200 years ago, So river estuary been a broad, providing deposition plains Giao Thuy-Hai Hau [1], [24], [26], [54]. Until now this role is almost lost.

- Incident expansion mutation Ba Lat estuary and sedimentation area of the Ha Lan estuary: The moment a decline sudden of deposition So river coincided with the "Ba Lat pha hoi" [26], [54]. In 1787, a huge flood on the Red River has opened Ba Lat estuary to flow into the sea [26].

- Ninh Co river and developments Lach Giang estuary: Northern Lach Giang, from 1961-2001, -5.0m contour toward land average 1200m, 0,0m contour toward land average 250m. From 1961-2001 Thinh Long nose toward southward nearly 2500m, but from 2001-2011, the 1000m short erosion [24], [26] , [54].

3.1.2. Trend deposition - erosion in Hai Hau in modern times:

Before the expansion mutation events Ba Lat, on a stretch of nearly 20.0km between So river and Ninh Co river, about 300 years, the mainland has developed to the sea at a rate of 30m/year. Products mainly deposition clay soil types [11], [15], [22], [32], [34]. Since shrunk So river, erosion process began, starting from Hai Dong, Hai Ly, the trend of erosion spread south and continues to this day.

3.2. Analysing developments, determine the type of profile characterizes in Hai Hau area.

Observed data (beach profiles and sediment) in Hai Hau from 1985 to 2010 was conducted by the Vietnam Academy for Water Resources [40], [41], [42], [43], [46]. Choice 3 profiles represent Hai Hau areas: HH01 (northern), HH02 (middle), HH03 (southern).

3.2.1. Analysis of some rule beach profile changes in each period

Some general rules of beach profile change here as follows:

- In the southwest monsoon the beach average accreted 0.10 ÷ 0.15m. Northeast monsoon beach eroded, averaging 0.4 ÷ 0.5m.

- If the storm encountered low tide, beach erosion processes occurring intense. If storm surges encountered beach erosion and erosion processes dykes occur.

- Beach is increasingly being narrowed by the accumulation of the annual erosion that is most intense during the "Nuoc ruoi".

- Diameter of sand D_{50} in Hai Hau was "bigger" compared to the period in 1975 showed that sediment from the river to reduction.

- Within 40 years erosion tend gradually to the south.

3.2.2. Type of profile characterizes in Hai Hau - Nam Dinh area

- Choice the type of profile characteristics suitable study areas: Considering the three function to describe profile equilibrium [78]:

+ Basic function: $y(x) = A(x + x_s)^{\rho}$ (3.1)

+ Exponential Komar and McDougal: $y(x) = B(1 - e^{-kx+C})$ (3.2)

+ Logarithmic function (Lee-1994): $h(x)=D+1/F.\ln(x/G+1)$ (3.3)

Calculation method suitable curve (Table 3.1).

Table 3.1. Specific coefficient for each form of equation

Functional form	**Coefficient**	**MC HH1**	**MC HH2**	**MC HH3**
$h(x)= A(x + x_s)^{\rho}$ (Funtion[1])	$A(m^{1-\rho})$	-0,012	-0,174	-0,040
	$x_s(m)$	-1,000	-1,000	-1,000
	ρ	0,568	0,472	0,695
	R	0,862	0,944	0,898
	RMSE	0,568	0,256	0,484
h(x)= B(1-exp(-kx+C)) (Funtion[2])	*B (m)*	-	-4,635	-5,404
	C	-	-0,070	0,147
	$k\ (m^{-1})$	-	0,003	0,002
	R	-	0,949	0,945
	RMSE	-	0,245	0,354
h(x) = D + 1/F.ln(x/G+1) (Funtion[3])	*D(m)*	4,032	0,864	1,342
	$F(m^{-1})$	0,435	0,693	0,393
	G(m)	30,590	27,840	101,3 0
	R	0,940	0,963	0,964
	RMSE	0,292	0,209	0,373

Considering the coefficient shows that equation (3.3) is the best suitability. From equation (3.3) we can calculate and provide specific profiles in Hai Hau by: period, regions and seasons different.

- Calculated balance profile study area: The results showed that despite cross shore transportation caused beach deposition, but longshore transport a decisive role should the general trend in Hai Hau nearshore has eroded. This also demonstrates further the identification of Hai Hau areas longshore sediment transport is crucial to the process of erosion, deposition beach, shore.

3.3. Determining the cause of instability for the beach, shore in Hai Hau-Nam Dinh

3.3.1. Determining some general cause:

1) In view of the geologists general, the effect of the new role tectonic subsidence to the erosion in Hai Hau is relatively small compared to the exogenous causes [15], [22], [33], [37].

2) The phenomenon of erosion occur regularly throughout the year, but stronger in the winter when wave combine with high tides attack to sea dike, causing beach erosion and affecting the stability of dikes [3], [7], [36].

3) Velocity along the shore in Hai Hau relatively large in northeast monsoon, especially in the period of "Nuoc ruoi" [35], [38], [39] have a decisive effect to the erosion of the beach, dikes here.

4) Most of the calculation results of sediment transport in Hai Hau nearshore shows the amount carried away more than bring [34], [60]. Thus occurs imbalance serious sediment.

3.3.2. Movements of Ba Lat morphological processes affecting coastal erosion study area

1) Since shrunk So river (period "Ba Lat pha hoi") [1], [26], [54] and pond up after the flood in 1971 for the loss of sediment source supply for Hai Hau causing exacerbate imbalances sediment.

2) The Ba Lat estuary formed by accreting mudflats towards the sea as a natural groin. Along with that, the gradual erosion move from north to south in Hai Hau [34], [36], [54].

3) The phenomenon of forest degradation, the operation of the Hoa Binh lake reduce the amount of sediment [48], [54].

3.4. Conclusion for Chapter 3

- Some rule beach changes and the type of profile characterizes in Hai Hau area as follows:

+ In Hai Hau, often eroded beaches on the northeast monsoon and deposition in the southwest monsoon season, the value of erosion greater deposition.

+ In the area of Hai Hau happen imbalance serious sediment, sediment from the river to reduction.

+ Within 40 years erosion in Hai Hau tend gradually to the south.

+ Recommend specific equations suitable profile for Hai Hau area logarithm form: **h(x) = D + 1/F.ln (x/G + 1)**.

+ Results based equilibrium theory profile of Dean (1977) showing the longshore transport plays a decisive role, so the trend in Hai Hau is eroded beaches.

- From the measured data, the collection, analysis has shown the cause of instability for the beach, shore Hai Hau area.

Chapter 4. RESULTS OF EXPERIMENTS ON PHYSICAL MODELS AND NUMERICAL SIMULATIONS OF THE TECHNICAL PARAMETERS OF SUBMERGE DIKES PROTECTING THE SHORE AND MORPHOLOGICAL CHANGES IN HAI HAU

4.1. Results of experiments on physical models

Experiment on physical models to find the reduce of the wave height coefficient $K_t = H_{st}/H_{si}$ (H_{si}, H_{st} is the wave height before and after dike) to over submerge dikes when varying parameters such as: elevation dike crest (Δ), crest width (B) and the slope coefficient (m).

4.1.1. Experiment choice elevation dike crest underground: experiment with submerge dikes has (B) a fixed B = 5.0m (B_{MH} = 25cm), slope $m_1 = m_2$ = 1:2. From the results (Figure 4.1), shows: For effective submerge dikes is d/h > 0.5 for K_t = 0.8 ÷ 0.7, the minimum wave height reduction of 20% ÷ 30%. Proposal Δ with design water level frequency P = 5% (h = 2.2m) + 0.8m surges: submerge dikes located at -1,0m bottom elevation, with h = 2.2 + 0.8 + 1.0 = 4.0m, choice d/h = 0.6 (or greater, depending on the purpose and possibilities of investment), also d = 4.0 x 0.6 = 2.40m. Then: Δ = 2.40 - 1.0 = + 1,40m.

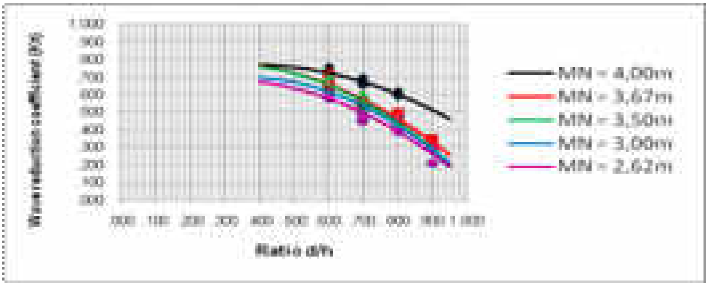


Figure 4.1. Relations between K_t and d/h with WL correspondingly

4.1.2. Choice parameter underground dike crest width: Fixed with submerge dikes: $\Delta = +1.40$m, $m_1 = m_2 = 1:2$, submerge dikes located at -1,0m bottom elevation. Varying B = 3 ÷ 15m. Results show that when B = 5.0m, the average coefficient K_t in the case is $K_t \approx 0,38 \div 0.48$. When B increases, the ability to reduce the wave of submerge dikes increased but not much, so choose B suitable.

4.1.3. Choices for dike slope coefficient underground: Fixed $\Delta = +1,40$m, B = 5.0m, submerge dikes located at -1,0m bottom elevation. Varying the slope m = 1.5 ÷ 4.0. Results showed that when the m larger then K_t decreases, but the decrease is not much, so choose m suitable.

Based on the results already experiment, legacy data, results of previous studies on the physical model of wave reduction submerge dikes for Hai Hau area [44], [47], conducting statistical analysis given the relationship between the water levels were experiment and coefficient K_t with placement and technical parameters choice of submerge dikes. Extract the value K_t corresponding to the requirements of Genesis as input model calculations (Table 4.1).

Table 4.1. K_t extract value corresponding to the WL calculations

No	**K_t**	**Water level (m)**	**Placement of underground dike**
1	0,366	1,86 (d/h = 0,81)	50m from shore, bottom elevation -0,60m
2	0,343	1,86 (d/h = 0,82)	80m from shore, bottom elevation -0,75m
3	0,321	1,86 (d/h = 0,83)	100m from shore, bottom elevation -0,85m
4	0,298	1,86 (d/h = 0,84)	150m from shore, bottom elevation -1,00m
5	0,275	1,86 (d/h = 0,85)	200m from shore, bottom elevation -1,20m

4.1.4. General assessment: Choice, proposed the structure parameters appropriate for Hai Hau: Δ=+1.4; B=3.0÷5.0m; m = 1:2.

4.2. Study results on the mathematical model simulation

4.2.1. Effect of the reduce wave structure to shoreline morphology

- Influence of submerge dikes length to morphology: The results showed that, when increasing the submerge dikes length, shoreline tends to be more stable. All cases for deposition-erosion balance is positive, indicating a protective coast effect against erosion of submerge dikes is promoted.

- Influence of the distance between the dike and the original shoreline (X) to the morphology: When increasing X, both deposition and erosion area were reduced. So, the put submerge dikes further away shoreline will reduce local deposition-erosion. The balance of deposition-erosion in all cases were positive features.

- Influence of gap width (G) between the underground dike to morphology: When increasing (G) alluvial area has not varied much but the area of erosion increases. So the value of the balance of deposition-erosion decreases as (G) increases.

4.2.2. Choice the suitable parameter structures based on the study results were calculated

Based on empirical formula, combining calculation mathematical models and physical model to choose on submerge dikes parameters for the Hai Hau [61], [64], [65], [79], [80], (see [83], [84], [85], [86]).

Table 4.1. The technical parameters of the proposals for submerge dikes in Hai Hau

Technical parameters	Value proposals	Note
Distance from the shore to the submerge dikes (X)	(120÷170)m	Thesis proposes X=150m
submerge dikes length (L)	(200÷300)m	Thesis proposes L=200m
submerge dikes spacing (G)	(90÷110)m	Thesis proposes G=110m
Crest width (B)	(3,0÷5,0)m	Thesis proposes B=5m
Crest elevation (Δ)	> +1,30m	Thesis proposes Δ=+1,40m
Two slope (m_1, m_2)	1:2	Slope on both sides

4.2.3. Calculate regime geohydrodynamics with proposals structure for study area

1. Calculation results beach changes and prediction shoreline changes with natural beach:

- Calculate beach changes: In the northeast monsoon, beach erosion, to southwest monsoon, beaches tend to compensate, however slight amount of compensation. Calculations for the region Hai Trieu - Hai Hoa, in one year at this beach sediment lost about $105.10^3 m^3$/year.

- Prediction shoreline changes in natural conditions: the general trend in the 10 years (2009-2020), the natural coastline in Hai Hau persist erosion process, the extent depending on the location. The results also demonstrate the conclusion of one of the main causes leading to instability, causing erosion of the shores of Hai Hau is due to alongshore current.

2. Calculate the training plan in Hai Trieu - Hai Hoa area:

- Calculate beach changes as systematic training structures: The system structures to prevent about 40% of sediment loss make deposition inside the building. Total sediment lost when structures are hereby reduced to about $75.10^3 m^3$/year.

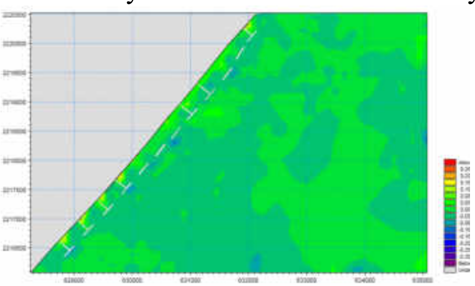


Figure 4.2. Morphology structure area (PA4 – wave direction 45^0)

Figure 4.3. Evolutions in Hai Hau shore when structures

- Calculation results shoreline changes after training structures: Calculation results show that the arrangement proposed structures system was created to deposition, protect Hai Hau beaches (Figure 4.3).

4.3. Propose solution to prevent erosion and protect Hai Hau beaches, sea dike

4.3.1. Assess the effectiveness of reduce wave structures, causing deposition on the beach made in Hai Hau

1. The effect structures: So far, the case using T groin are effective for not large, but positive, they cause compensation inside buildings (T groin in Hai Thinh 2, sand traps in Kien Chinh) and reducing wave when through submerge dike .

2. These problems exist:

- T groin: Groin shank not to strip breaker, short groin nose (Hai Thinh 2), little deposit. T groins crest elevation not reached the mean water level, restrictions prevent sand and wave as high water level, waves. Structural of groin nose using the tube, effectively reducing the wave very limited, and cause reflected wave, resulting in toe dike scour, detrimental to stabilize the building.

- Sand trap: Placement of submerge dikes (dike body) too close to shore and low elevation, no effective reduction waves, sand prevent. As directed, the position from coast to submerge dikes by (1.0 ÷ 1.5) the wave length in deep water. Submerge dikes length (nose), as directed by (1.5 ÷ 3.0) the distance from the shore to the submerge dikes. The design of the sand trap is 1.0 times as small disasters.

3. Choice a solution for the shore need to training: type groins perpendicular to the shore combined with submerge dikes would effectively reduce the waves, creating deposition and shore protection in Hai Hau. The choice is based on the principle of reasonable space layout structures with topographic conditions, the geo-hydrodynamic regime in Hai Hau. On the other hand draw experience from projects already built before and the actual structure is effective in Nam Dinh,... and the results of the simulation calculations on mathematical models, physical models.

4.3.2. Planning of coast protection structures in Hai Hau area

Hai Hau area can be divided according to 03 levels: *(a)- Dangerous route:* Hai Ly, Hai Chinh, Hai Trieu, Hai Hoa, Hai Thinh. *(b)- Very dangerous areas:* Hai Trieu, Hai Hoa-Con Tron, Hai Thinh. *(c)- Less dangerous route:* No2 sea dikes route, Ha Lan area. From results of the research of reducing wave submerge dikes, T groins , has proposed structures plan for Hai Trieu - Hai Hoa area include: 7 T groins combined 5 submerge dikes.

4.4. Conclusion for Chapter 4

From the results of physical model have chosen, the proposed submerge dikes specifications for Hai Hau area: $\Delta = +1.4$ (or higher, depending on the purpose and the ability to invest), $B = 3.0 \div 5.0$m, $m_1 = m_2 = 1:2$. Extract the coefficient K_t corresponding to the parameters and location of structures at water level, put into simulation calculations shoreline changes by model Genesis when use the reducing wave structures.

Numerical models have been very useful for choosing of size, location, as well as combinations of structure and assess the effectiveness of the structure plan layout on the beach.

Combining numerical models and physical model will give the best choice of reducing wave and creating deposition structures for Hai Hau area.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

1. The dissertation has initially identified some of rules, relationships of beach profile change, effect of the dynamics regime, especially wave based data chain measured for long-term conditions of wind and wave during the Northeast, the Southwest monsoon in the study area. From the measurement data many years representing each region along Hai Hau coast, statistical analysis and proposal application forms characteristic equation for the area is logarithmic format (equation 3.6), the parameters in the equation is represented for local and express the rule changes of coastal area.

2. Define the cause of deposition, erosion and instability Hai Hau beach help choose training propose for coastal area based on historical documents, remote sensing document, measurement data,... then conducting superpose periods map, analyze morphological changes estuaries and statistical analysis of measurement data.

3. Results on physical modeling shows, with submerge dike system standard d/h> 0.5, the reduction waves coefficient K_t reached to the average value between 0.7 ÷ 0, 8 corresponds to the wave height was least reduced from 20% ÷ 30% after structure. For Hai Hau area, the thesis proposed submerge dikes crest elevation design to the frequency water level P = 5% (water level = 2.2m), plus 0.8m surge water level is d/h = 0.6 (or may be greater, depending on the purpose and the ability to invest), the dike crest elevation will be Δ = + 1,40m, crest width B = (3.0 ÷ 5.0) m, slope (m_1, m_2) = 1:2. When submerge dikes will reduce minimum 25% ÷ 45% wave height after dike (depending on high or low tide). Also from the results of experiments will choose the reduce wave coefficient K_t corresponding to the water level, to serve as input to

calculate scenarios shoreline changes GENESIS models in Hai Hau when has wave reduction and created deposition structures systems.

4. The results of simulation studies on numerical modelsto assess the affect of structures to the shoreline changes in Hai Hau with different options of location (far, near to the shore), size (long, short), and the gap between structures. From that choosing size, structures position on beach to improve the efficiency of the structure.

5. The thesis has proposed structures to reduce the wave and creating deposition and stable beach, shore in Hai Trieu - Hai Hoa location of Hai Hau district where has 05 submerge dikes combined with 07 T groins.

B. Recommendation

The study results have scientific and practical, provided the scientific basis for choosing reduce wave and causing deposition solutions on beaches to prevent and minimize disaster, protect beaches, shores in Hai Hau area. However, due to the extensive and complex field studies some issues existed such as: effects of river flow in study area, the material used for the submerge dikes, the cover blocks submerge dike, reinforcement toe dike plan, .. should be further study to promote the best efficiency of buildings in practical application.

LIST OF AUTHOR'S PUBLICATIONS RELATED TO THE THESIS

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2. **Doan Tien Ha**, Mac Van Dan(2013), *The application CEDAS model to calculate, forecast fluctuation of shoreline in Sam Son area belong to Thanh Hoa province.* Water Resources Science and Technology Journal, No 13-2013, Page 34-43;

3. Truong Van Bon, Vu Van Ngoc, **Doan Tien Ha** (2013), *Results of tidal and coastal sediment transport calculated by mathematical models from Lap estuary to Loc An estuary in Ba Ria-Vung Tau.* Water Resources Science and Technology Journal, No 13-2013, Page. 2-6;

4. **Doan Tien Ha** (2013), *Research, simulate the effects of terrain and regulation works on the beach to wave transmission and wave height in some estuaries and coastal belong to Nam Dinh province.* Water Resources Science and Technology Journal, No 18-2013, Page. 61-68;

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7. **Doan Tien Ha**, Tran Hong Thai, Truong Van Bon (2015), *Study and propose the parameters of structure to reduce wave causing damages for Hai Hau, Nam Dinh province.* Water Resources Science and Technology Journal, No 25, 2 - 2015, Page. 100 - 110.