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**PROCEEDINGS OF THE 4th INTERNATIONAL CONFERENCE
VIETGEO 2018, QUANG BINH, 21-22 SEPTEMBER, 2018**

**GEOLOGICAL AND GEOTECHNICAL
ENGINEERING IN RESPONSE TO CLIMATE CHANGE
AND SUSTAINABLE DEVELOPMENT OF INFRASTRUCTURE**



SCIENCE AND TECHNICS PUBLISHING HOUSE



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Quang Binh, 21&22 September 2018

INTERNATIONAL CONFERENCE VIETGEO 2018

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QUANG BINH, VIETNAM

Organized by

Vietnam Association of Engineering Geology and the Environment (VAEGE)
Hanoi University of Mining and Geology (HUMG)
Quang Binh Department of Science and Technology
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TABLE OF CONTENT

Preface	x
----------------------	---

SESSION 1 GEOLOGICAL AND GEOTECHNICAL ENGINEERING IN RESPONSE TO CLIMATE CHANGE

Assessing the resilience of Bac Bo Plain, Vietnam under the impacts of climate change: case study in Hai Dong commune <i>Do Minh Duc, Duong Thi Toan, Tran Thi Luu</i>	3
Impacts of global climate change, sea level rise and economic-contruction activity to the sustainable development of the Quang Ninh coastal area <i>Le Trong Thang</i>	14
Bioengineering approach for shoreline protection using geosynthetics: A malaysian experience <i>L.K.Lim, Y.J.Fong</i>	23
Properties of soft soil ground in the Quang Ninh coastal area and proposal of soft soil improvement in the context of the climate change and sea level rise <i>Nguyen Thi Nu, Nguyen Van Phong, Do Minh Toan, Nguyen Viet Tinh, Pham Thi Ngoc Ha</i>	32
Erosion and accretion at the estuaries of Quang Binh province in the period of 2000 to 2016 <i>Do Quang Thien, Ho Trung Thanh, Nguyen Quang Tuan, La Duong Hai, Le Thi Cat Tuong, Tran Thi Ngoc Quynh</i>	38
Effects of climate change on slope stabilization in the Cao Son coal waste area, Cam Pha, Quang Ninh <i>To Xuan Vu, Nguyen Van Hung, To Hoang Nam</i>	52
Effects of fine particles and water content on shear strength and riverbank stability: A case study in the Red riverbank in Hanoi area <i>Duong Thi Toan, Ngo Hong Hue</i>	62
Evaluation of adaptive capacity to salinity intrusion of the Da Nang city in the context of climate change <i>Nguyen Ngoc Truc, Nguyen Thi Oanh, Ho Xuan Huong</i>	71
Effects of capillary water on groundwater in coastal sand dunes in the North Central Region of Vietnam <i>Nguyen Thanh Cong, Nguyen Huy Vuong, Pham Tuan, Tran Van Quang, Vu Ba Thao, Bui Truong Son</i>	79
The neotectonic and active tectonic influence on coastal erosion at Quang Nam province of Vietnam <i>Hoang Ngo Tu Do, Do Quang Thien, Tran Thanh Hai, Le Thanh Phong</i>	84
Impacts of climate change on the Upper - Middle Pleistocene aquifer in the Ca Mau peninsula and adaptive solutions <i>Dao Hong Hai, Nguyen Viet Ky, Bui Tran Vuong</i>	89

SESSION 2
**GEOTECHNICS FOR SUSTAINABLE DEVELOPMENT
 OF INFRASTRUCTURE**

Physical scale model of horizontal water collecting system for weirs in the Northwest Vietnam <i>Nguyen Huy Vuong, Nguyen Chi Thanh, Pham Tuan, Tran Van Quang, Le Vu Minh, Vu Ba Thao, Bui Truong Son</i>	101
Settlement of saturated clay layer subjected to cyclic loading with a wide range of loading periods <i>Hiroshi Matsuda, Tran Thanh Nhan, Hiroyuki Hara</i>	110
A case study on the determination of the excavated trench depth in unsaturated soil constructed by open trench method without supporting structures <i>Nguyen Xuan Man, Le Van Hung, Kenneydy Chibuzor ONYELOWE</i>	121
A method of evaluation of wave loads acting on vertical pier with non-prismatic section in the deep sea <i>Dang Xuan Truong, Dau Van Ngo, Le Van Nam</i>	130
Classifying the foundation structure for sustainable planning and development of Hanoi urban center <i>Tran Manh Lieu, Nguyen Huy Phuong, Duong Thi Toan, Tran Thi Luu, Nguyen Van Vu, Nguyen Van Thuong, Nguyen Ngoc Truc</i>	135
Establishing geology engineering map of the Hai Thinh area for planning of eco-social sustainable development <i>To Hoang Nam, To Xuan Vu</i>	142
Application of acoustic waves for assessment of excavation damaged zone for underground construction in rock mass <i>Hoang Dinh Phuc, Chu Viet Thuc</i>	149
Calculating the large two-way batter bearing pile foundation for pillar supported dam <i>Tran Van Thai, Nguyen Dinh Truong</i>	160
Influence of embankment height and soil parameters on piled embankments by 3D numerical simulation <i>Pham Van Hung, Vu Minh Ngan</i>	172
Application of transformation theory of engineering geological properties of soils to determine the distribution of Hai Hung formation in the Hanoi area <i>Ta Duc Thinh</i>	180
Analysis of metal pollution in groundwater of Pleistocene aquifer in Ho Chi Minh city, Vietnam <i>Tran Thi Phi Oanh, Nguyen Viet Ky, Dau Van Ngo, Ho Chi Thong, Mai Hoang Phuc , Nguyen Thi Ngoc Thuy</i>	184
Evaluation of the operating capacity of ports based on the analysis of hydrodynamics and the erosion - accretion regulation of the coastal areas in the North Vietnam <i>Nguyen Huy Phuong, Duong Van Binh, Nguyen Huy Quang</i>	195
Characteristics of cyclic deformation phases of soils distributed in the urban area of Hanoi for seismic design <i>Nguyen Van Phong</i>	201
The sand-cement-lime column method for soil improvement: A case study in Tay Thai Thuy High school, Thai Binh province <i>Ta Duc Thinh, Nguyen Duc Ly</i>	207

Effects of lime on improving swelling characteristics of the soil weathered from acidic magmatic rock in Central Highlands of Vietnam <i>Nguyen Huy Vuong, Vu Ba Thao, Dang Hoang Thanh, Nguyen Manh Ha, Bui Truong Son, Pham Tuan, Dinh Van Thuc, Tran Van Quang</i>	215
Soil improvement through biological-based method <i>Pham Phu Vinh, Leon A. van Paassen</i>	225
Residual shear strength of soil and its shear displacement rate dependency: an overview <i>Motoyuki Suzuki, Nguyen Thanh Duong</i>	233
Application of Roclab software in defining the mechanical characteristics of contact rock in dam foundation for small-scale hydroelectric projects: A Case study in the Long Tao hydroelectric project, Dien Bien province <i>Bui Truong Son, Vu Thai Linh</i>	246
Consolidation properties of some Holocene soft clayey soils in the Quang Nam - Da Nang coastal plain <i>Nguyen Thi Ngoc Yen, Nguyen Hoang Giang, Do Quang Thien</i>	253
Effects of cycle number of triaxial cyclic test and sand density on dynamic properties of sand of the Thai Binh formation in Hanoi area <i>Nguyen Van Hung, Nguyen Thanh Duong, Bui Van Binh, Phung Huu Hai, Pham Thi Ngoc Ha</i>	263
Effects of soft ground structure on the Hau riverbank failure process in An Giang province, Vietnam <i>Tran Le The Dien, Huynh Trung Tin, Trang Nguyen Dang Khoa, Bui Trong Vinh, Ta Duc Thinh</i>	268
Effects of undrained cyclic shear and Atterberg's limits on the secondary consolidation of soft soils <i>Tran Thanh Nhan, Hiroshi Matsuda, Hoang Thi Sinh Huong, Hidemasa Sato, Do Quang Thien, Duong Phuoc Huy, Nguyen Van Thien, Lai Phuoc Thanh Hoai, Vo Thanh Men, Tran Thi Anh Dai, Nhu Viet Ha</i>	278
Downhole seismic testing to determine elastic parameters of the ground for anti - seismic designs: A case study in the industrial zone Vung Ro, Phu Yen <i>Bui Truong Son, Vu Thai Linh</i>	287
Evaluation of sand-cement column solution for soft soil improvement in the North Coastal Highway, Vietnam <i>Nguyen Thi Dieu, Ta Duc Thinh, Nguyen Duc Manh</i>	294
Study, analysis and assess effectiveness of soft soil improvement using PVD combine vacuum preloading at hyosung vina chemicals project at Ba Ria Vung Tau province, Vietnam <i>Phan Thanh Tien, Nguyen Tan Son</i>	303

SESSION 3

GEOTECHNICAL MONITORING AND MATERIALS

Assesment of capability of using natural puzzolan in Dak Nong, Viet Nam for soil stabilization <i>Vu Ba Thao, Nguyen Huu Nam, Pham Van Minh, Tran Van Quan, Nguyen Huy Vuong, Dinh Van Thuc</i>	312
Comparison of numerical modeling and field monitoring of deep foundation of high-rise building: A case study of Summit Building, Tran Duy Hung, Hanoi, Vietnam <i>Bui Truong Son, Duong Van Binh, Nguyen Thi Trang</i>	320
Scientific basis for setting up a monitoring system for geo-environmental disaster prevention and sustainable development of the Red River dynamic zone in Hanoi <i>Nguyen Cong Kien</i>	329

Using coal bottom ash of An Khanh thermal power plant as aggregate replacement of concrete <i>Nguyen Thi Nu, Bui Truong Son</i>	338
Propose new approach method to determine scale module for granular soils in serve of natural building materials Application for Granular Soils in Quang Tri -Thua Thien Hue Coastal Plain) <i>Do Quang Thien, Dang Quoc Tien, Ho Trung Thanh, Le Thi Cat Tuong, Tran Thi Ngoc Quynh</i>	342
Effect of particle size distribution of Liem Son, Kim Bang, Ha Nam limestone grading as inert additive on But Son cement Motar <i>Ta Thi Toan, Nguyen Thi Nu, Vu Thi Ngoc Minh</i>	350
The Basic characteristics and applicability of granulated blast furnace slag (GBFS) as building materials in Vietnam <i>Nguyen Ngoc Truc, Nguyen Van Vu, Nguyen Thi Oanh</i>	357
Reusability the bottom ash from coal thermal power plant (CTPP) for graded materials and concrete aggregate based on particle size distribution <i>Nguyen Thi Nu, Nguyen Ngoc Dung, Nhu Viet Ha, Duong Van Binh, Phan Tu Huong, Ta Thi Toan</i>	365
Exploring the potential of high-accuracy landslide detection and monitoring based on new remote sensing data and techniques <i>Nhu Viet Ha</i>	373

SESSION 4 GEOHAZARDS AND SLOPE STABILITY

Remedy of a collapsed riverbank protection structure in Thailand <i>Suksun Horpibulsuk, Artit Udcomchai, Menglim Hoy, Arul Arulrajah</i>	387
Analysis the causes of land subsidence in Ca Mau city <i>Dao Hong Hai, Nguyen Viet Ky, Tra Thanh Sang</i>	396
Using logistic regression and neural networks for landslide susceptibility assessment along the transport arteries in the mountainous areas of Quang Nam province <i>Do Minh Duc, Nguyen Khac Hoang Giang , Dao Minh Duc , Do Minh Ngoc, Dinh Thi Quynh, Dang Thi Thuy, Nguyen Huu Ha, Nguyen Van Binh, Hoang Hai Yen , Do Van Vung</i>	403
Probabilistic Monte Carlo simulation for assessment the slope instability due to rainfall on the Nha Trang - Da Lat route <i>Nguyen Thanh Danh, Dau Van Ngo, Ta Quoc Dung, Nguyen Huu Son</i>	412
Factors triggering landslides in timor-leste <i>Benjamim Hopffer Martins, Motoyuki Suzuki, Eguchi Tsuyoshi, Noppawan Tamkuan, Masahiko Nagai</i>	421
Landslide hazard and prevention in the Ward 2, Dalat city, Vietnam <i>Nguyen Viet Ky, Bui Trong Vinh, Kanno Takami</i>	431
Safety assessment of a creeping landslide based on field measurements <i>Nguyen Tai Son, Pham Van Ty, Le Quang Huy</i>	438
Rainfall-induced shallow landslides: Behavior and mitigation approach <i>Avirut Chinkulkijniwat, Somjai Yubochit</i>	445
Assessment, classification and solutions for landslide mitigation along the National Highway No. 6 <i>Tran Manh Lieu, Duong Thi Toan, Tran Thi Luu, Nguyen Ngoc Truc</i>	461

Examining the reliability of the logarithmic sliding surface method in slope stability analysis <i>Pham Huu Sy, Pham Phu Vinh, Le Vu Minh</i>	472
Application of artificial neural networks for landslide forecasting models in the mountainous areas of Xin Man district, Ha Giang province <i>Pham Quoc Khanh, Nguyen Thi Kim Thanh</i>	477
Causes of landslide in the Ong Tuong hill area, Hoa Binh city and treatment solutions <i>Duong Van Binh, Bui Truong Son, Pham Thi Ngoc Ha, Nguyen Minh Hien</i>	484
Probabilistic analysis of rainfall-induced landslides in Quang Nam province <i>Nguyen Khac Hoang Giang, Trinh Quoc Anh, Dang Thi Thuy, Do Minh Ngoc, Dao Minh Duc, Hoang Hai Yen, Nguyen Huu Ha, Do Minh Duc</i>	492
Analysis of pore water pressure and slope displacement by historical rain series in Xin Man district, Ha Giang province, Vietnam <i>Dao Minh Duc, Tran Quoc Cuong, Do Minh Duc, Dang Thi Thuy</i>	499
Characteristics of geotechnical and environmental hazards in Hanoi area <i>Nguyen Van Vu, Nguyen Van Thuong, Nguyen Ngoc Truc</i>	510
Analysis of sediment distribution and transport trends at the Da Dien estuary, Central Vietnam <i>Dinh Thi Quynh, Do Minh Duc, Nguyen Tien Giang, Tran Ngoc Anh</i>	517
Slopes in loose rock - stabilisation and erosion protection in a single operation <i>Tran Dong, DENNIS Gross</i>	524

SESSION 5 TECHNICAL NOTES

Distribution and engineering properties of clayey soils of the Phu Bai formation in Thua Thien Hue and Quang Tri <i>Hoang Thi Sinh Huong, Tran Thanh Nhan, Pham Huu Tuyen, Do Quang Thien, Ho Sy Thai, Massimo Sarti</i>	533
Soft soil improvement with cement and fly ash in Vietnam <i>Chu Long Hai, Nguyen Chau Lan, Hoang Duc Chi, Nguyen Vinh, Nhu Tuan</i>	542
Soft soil improvement in the 2/9 Road (extension) project, Vinh Long town, Vinh Long province <i>Thai Ba Ngoc, Tran Van Xuan, Hoang Quang Trung Phi, Luong Bao Minh, Truong Xuan Hien, Vo The Anh</i>	552
Introduction to structure of the water filter solutions in boat pumping station for aquacultural water supply in the Ca Mau peninsula <i>Nguyen Quoc Dung, Phan Dinh Tuan, Le Anh Duc, Nguyen Quang Thanh</i>	564
Effects of hydraulic conductivity on the riverbank stability <i>Duong Thi Toan</i>	570
Discussion on nearly correct determination of shear strength of strongly weathered rock zone Ia2 <i>Bui Khoi Hung, Dang Hoang Cam, Ho Minh Long, Tran Xuan Sinh</i>	579
Using piezcone penetration testing of soils (CPTU) to determine the physico-mechanical properties of sand using for sea dykes in Tra Vinh coast, South Vietnam <i>Nguyen Huu Son, Dau Van Ngo, Ho Chi Thong, Nguyen Thi Ngoc Thuy</i>	584

EVALUATION OF THE OPERATING CAPACITY OF PORTS BASED ON THE ANALYSIS OF HYDRODYNAMICS AND THE EROSION - ACCRETION REGULATION OF THE COASTAL AREAS IN THE NORTH VIETNAM

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Abstract: In the coastal areas of Northern Vietnam, the interaction between the geological environment and the external environment (hydrosphere, atmosphere, biosphere) and socio-economic activities has performed and developed geodynamical processes. In those processes, the most important and prominent process is the erosion-accretion process. This process is very complex and changes with rules. It has a strong influence on marine economic activities in general and the exploitation of ports in particular. The analysis of dynamics and rules of the erosion-accretion is a scientific basis for the planning of the port construction and effective exploitation, as well as put forwards to clear the canals to ensure waterway traffic.

Keywords: coastal erosion; port; Northern Vietnam.

Geological features and natural conditions (meteorology - hydrology - oceanography) in the coastal areas in northern Vietnam are very complex and change by rules. The paper analyzes

the scientific basis to evaluate the exploitation of ports based on hydrodynamic conditions, dynamics and rules of formation and development of erosion and accretion of this region.

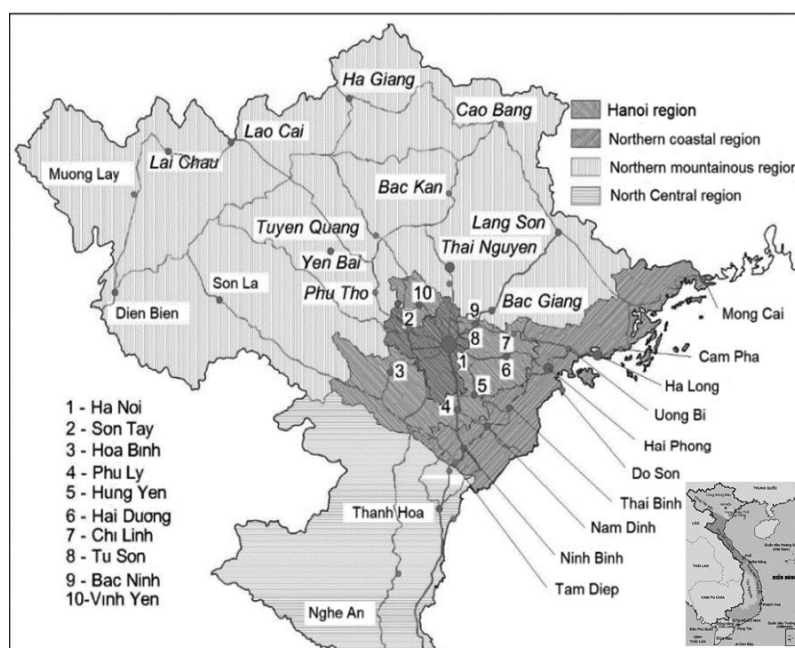


Fig. 1. Location of research “Northern coastal region”

1. The natural condition of the region

The topography of the region (from Quang Ninh to Ninh Binh) is mainly low plain, quite flat, only some hills and mountains in the north (from Mong Cai (Quang Ninh) to Do Son, Kien An (Hai Phong)). Mountain topography consists primarily of terrigenous sedimentary rocks or biochemical sedimentary rocks. Plains of 0.5-4.0 m in altitude are composed of soft sediment, intermingled with sandy beaches, tidal flat. Topography of shallow seafloor is subterranean delta, relatively flat with slope below 3 degrees. The topography is complicated by the channel system and bars at the river mouth. The development of the coastal zone creates typical terrain types: straight shorelines, tidal flats, tidal creeks, submarine zones ...The climate of the area is tropical monsoon, hot, humid, heavy rain and is divided into two distinct seasons. Therefore, it contributes to promote the erosion-accretion process.

2. Geohydrodynamic zoning in the region

Geohydrodynamic zoning is to build up a scientific basis for analyzing the causes, mechanisms, forming conditions and development rules of erosion and accretion.

Applying a general and systematic approaches, change theory, hydrodynamic theory, equilibrium theory to analyse the geohydrodynamic processes.

Assuming that the geohydrodynamic process is a system, it may include sub-systems of hydrogeological structure (geosystem) and hydrodynamic (waves, currents, and tide).

The interaction between the components of the system reflects the geohydrodynamic feature of the system and determines the erosion-accretion.

Thus, it is necessary to analyze the characteristics of the two components and evaluate their interactions.

2.1. Hydrogeological structure

2.1.1. Classification of hydrogeological classes

The coast is composed of many layers of rock and soil, which are resistant to erosion at varying degrees. These levels are evaluated according to the reducing strength when touching water or easy to destroy in water. Soft soil is classified by structural strength and sensitivity.

Cohesive soils, according to the structural strength, can be roughly classified according to

their state. Sandy soil has very low structural strength, so it is easy to erode. Rocks have a specially high architectural strength, should be classified as a special level.

The research results are classified into 5 levels as follows:

- Layers have a very low degree of erosion protection: Level I - Sand

- Layers have a low degree of erosion protection: Level II – Mud; Clayey sand; Sandy clay; clay, very soft.

- Layers have a medium degree of erosion protection: Level III – Clay; Sandy clay, soft-firm; Clayey sand, plastic

- Layers have a high degree of erosion protection: Level IV – Clay; Sandy clay, stiff-very stiff

- Layers have a special high degree of erosion protection: Level V – Bedrock

2.1.2. Hydrogeological structure

As erosion occurs mainly in layers above the ground, the depth of the classification is about 15-20 meters. They are mainly Holocene sediments in the distribution areas of Quaternary sediments, the bedrocks are terrigenous sediments and biochemical sediments. They have been evaluated and classified according to the erosion levels that mentioned above, so that they can be selected as criteria for classification of hydrogeological structure.

The research region is classified into five types of structure as follows:

- Type A has a very low degree of erosion protection (level I) as sand.

- Type B has a low degree of erosion protection (level II) as mud.

- Type C layers with moderate levels of erosion protection (level III, IV) are sticky soils.

- Type D₁ has a particularly high erosion grade (level V) as terrigenous sedimentary rocks.

- Type D₂ has a special high level of erosion protection (level V) that is biochemical sedimentary rocks.

2.2. Hydrodynamic zoning

Hydrodynamic zoning reflects the mechanism and intensity of river flow, sediment flow, coastal currents, waves, and tide, which are factors that cause erosion.

The research results are classified into two areas as follows:

- Zone I: Coastal area from Mong Cai (Quang Ninh) to Yen Hung (Hai Phong).

- Zone II: Coastal area from Hai Phong to Ninh Binh.

2.2.1. Coastal area from Mong Cai (Quang Ninh) - Yen Hung (Hai Phong)

Low flow discharge, low flow of sediment, about $0.079 \cdot 10^6$ tons. The sea current flows from Hai Phong to Quang Ninh and rounds the sea. The dry season (April - November) is a tidal diurnal. During high tidal period, the tide level is 2.6-3.6 m; during low tidal period, the tide level is 0.5-1.0m. The waves are mainly in the direction of northeast wind, followed by the direction of North and East winds. The southwest flow is the main flow (Mong Cai - Hai Phong).

In May to October, the southeastern wind is mainly, the average sea wave is 0.7-0.9 meters, the maximum is 3.5-4.5 meters. The main flow is the North East (Hai Phong to Mong Cai). The average

flow rate is from 15 to 40 cm/s. The rate of flood tide is 25-35 cm/s, the rate of ebb tide is 30-100 m/s.

2.2.2. Coastal area from Hai Phong to Ninh Binh

This area has many large rivers, river flow has a great impact on erosion-accretion.

System of Red river - Thai Binh river has a large amount of water. Red River flow (through Son Tay) reached 118 billion m^3 , equivalent to $3743m^3/s$. Including both Thai Binh river and Day river, the total flow discharge is up to 135 billion m^3 . Heavy rainy season usually occurs in July and August. Red river dyke system is 5000km long. Therefore, the flow mainly flows to the sea, there is no overflow on the face. In the dry season, the flow discharge is low. The total amount of sediment transported through the main river mouths is as follows:

Tab. 1. Annual average amount of sediment deposited in estuaries of the Red river and Thai Binh river

No	Estuary	Total amount of sediment (10^6 tons)
1	Day	19.312
2	Lach Giang	2.577
3	Ba Lat	27.774
4	Tra Ly	9.003
5	Nam Trieu	5.0
6	Van Uc	11.0

Coastal flow is strongly influenced by the season. In general, the flow from north to south in winter and vice versa in summer. In the estuary area, the flow is very complex due to high river flow dynamics.

The tide is the diurnal tide. The flood tide level is 3.0-3.5m, average 1.7-1.9m, minimum 0.3-0.5m, maximum tide level can reach 4.0m. Saline intrusion varies seasonally.

Sea waves change with the seasons. In winter, the wave direction is mainly East, Southeast, North East; The wave level is 0.4-0.9m, the highest is 0.75-3.0m. In summer, the wave direction is mainly Southeast, South and Southwest, wave

level is 0.7-1.2m, the highest is 2.6-6m. In summer, there are usually higher waves due to storms.

The two regions have different hydrodynamic characteristics, so they have different roles causing erosion.

2.3. Geohydrodynamic zoning (corresponding to the erosion - accretion zoning)

The combination of geohydrological structure (five types) with two hydrodynamic zones allows us to classify into the 2 zones and 4 sub-zones geohydrodynamic zones. These zones have different erosion behavior characteristics, which are summarized in the following table:

Tab. 2. Geohydrodynamic zoning in the coastal areas in Northern Vietnam

Zone		Structural features	Hydraulic features	Erosion-Accretion
Zone I	Mong Cai to Yen Hung	<ul style="list-style-type: none"> - The sinuous shore - The structure of shore is rock - Coastal wetlands are very popular - There are few beaches - Many islands - Sea floor: Mud, sand, gravel - Mangrove is very popular 	<ul style="list-style-type: none"> - Short, steep river - Poor materials - High tidal tides, but tidal currents are severely divided by many islands - Small waves - The flow is not clearly defined 	<ul style="list-style-type: none"> - Slowly accretion, the shoreline is relatively stable. - The coastline from Mong Cai to Van Don is relatively untouched. - From Van Don to Yen Hung coast, the leveling process has developed strongly
	Hai Phong to Kim Son	<ul style="list-style-type: none"> - The coast is composed of loose and soft sediment - There is no island - The seabed composed of sediment such as sand, clayer sand, mud. 	<ul style="list-style-type: none"> - Long river, high river dynamics, seasonal change - River material is rich but uneven between rivers - Tide level is lower from Hai Phong to Kim Son - Strong waves, wave direction and intensity change with season and area - The coastal currents vary seasonally 	<ul style="list-style-type: none"> - Accretion prevails over erosion. - Erosion occurs strongly in Hai Hau. In other places, accretion and erosion occur alternately
Zone II	Sub-zone IIA Hai Phong to Diem Ho	<ul style="list-style-type: none"> - Coast to NE- SW. - Accumulative Plain - Sediment on the surface: sandy clay, clayer, clay, sand of Thai Binh Formation 	<ul style="list-style-type: none"> - Many rivers, characterized by large funicular estuary, NW- SE. - Tidal: diurnal tide, high - Waves, currents: <ul style="list-style-type: none"> + Winter: North, Northeast, East + Summer: SW, S, E. 	<ul style="list-style-type: none"> - Accretion is the main process - Erosion occurs alternately.
	Sub-zone IIB Diem Ho to Giao Thuy	<ul style="list-style-type: none"> - The N-S shoreline - Accretion occurs very strongly - Sediment: mainly sand dunes 	<ul style="list-style-type: none"> - Large estuaries in the direction of W-E. - Rich materials - Diurnal tide - Waves and currents <ul style="list-style-type: none"> + Winter: NE, E + Summer: S, SE, E; but Southern waves are almost non-effect on 	<ul style="list-style-type: none"> - The accretion occurs very strongly, the typical sand dunes develop.

Sub-zone IIC	Hai Hau to Thinh Long	<ul style="list-style-type: none"> - Straight seashore in the NE-SW direction - Sediment is mainly fine sand, very fine sand - Sea dykes, embankments and breakwaters. 	<ul style="list-style-type: none"> - There is almost no river so there is no material from the river - Diurnal tide. - Waves, flows vary with the season. + Winter: NE, E, SE. + Summer: S, SE, E. 	<ul style="list-style-type: none"> - Before the So estuary is filled, accretion occurs strongly. - Since the So estuary is filled, erosion occurs continuously.
Sub-zone IID	Nghia Hung to Kim Son	<ul style="list-style-type: none"> - The coastline is in the NE-SW and NW - SE. - Sediments are mainly sand dunes 	<ul style="list-style-type: none"> - There are two large river mouths, rich materials - The river is mainly N-S. - Diurnal tide. - The same wave as above. - The flow is mainly N-S 	<ul style="list-style-type: none"> - Accretion occurs most strongly.

3. Assessment of exploiting capacity of seaports

Zone I: From Mong Cai (Quang Ninh) to Yen Hung (Hai Phong):

Coastal areas are mainly rocky mountains, abrasive terrain and erosion mixed with small accretion. The topography varies greatly, with no large flat areas, the coast is jagged limestone so it is not convenient for the port layout. Rivers are small, the material is poor, seabed sediment is not significant. The depth of the sea changes rapidly from shore to sea.

Cua Ong, Cam Pha and Hon Gai ports are small ports that transport coal. Only Cai Lan area has good conditions for port development and relatively deep channel (20-22 meters at Bai Chay). However, due to Bai Chay bridge, it has limited capacity to exploit the port. To develop large ports, they have to go far away from the mainland, but these are limestone mountains so it is not feasible.

Zone II: From Hai Phong to Ninh Binh: Can be classified into two sub-zones:

Sub-zone IIA: From Yen Hung (Quang Ninh) to the end of Hai Phong.

Hai Phong coastal area is transition from rocky shore to soft sediment shore.

This area has a large river flowing into the sea, forming large canals to build ports. Due to the

strong interaction between the river and the sea, between the rivers, the seabed topography and the canal change strongly. The sedimentation rate here is higher than the erosion rate, but the total amount of sediment is limited so the coast is accreted but slow, usually 5-10 meters/year. Therefore, there are some convenient locations to build ports such as Dinh Vu, Lach Huyen.

However, accretion and erosion here still occur complicated, causing fluctuations in flow, deposition of canals. Therefore, in order to maintain port operation, dredging and clearing of canals should be carried out regularly.

The development of Hai Phong, Chua Ve, Dinh Vu, Lach Huyen ports is evidence of the development of accretion towards the sea, the coast moving away, the port also moved. That also shows that even Lach Huyen port will only have large capacity in certain time period. Therefore, in order to improve the port's exploitation efficiency, it is necessary to increase the scale of Lach Huyen port and orientation for long-term development.

Sub-zone IIB. From Thai Binh to Ninh Binh: The coastal area is composed of soft soil. Every year the mudflats grow hundreds of meters to the sea. The seabed has a small slope. The ability to build ports is not appropriate. From Thai Binh to

Ninh Binh, there are no suitable conditions for the construction of valuable ports.

The results of the actual survey of the ports is presented in the table below:

Tab. 3. Some major ports in Northern Vietnam

No	Zone	Port	Location	Capacity (DWT)	Navigable party	
					Length (Km)	Depth (m)
1	I	Cam Pha	Quang Ninh	65.000	40	7,4-11,0
2		Cai Lan		50.000	36	10,0-20,0
3		Vat Cach		3.000	20	3,7
4		Hai Phong		40.000	30,2	5,5-7,3
5	II	Cua Cam	Hai Phong	7000	20	5
6		Doan Xa		10.000	30	4,5
7		Transvina		12.000	42	5,7
8		Chua Ve				
9		Dinh Vu		40.000	7,6	5,7
10		Lach Huyen		100.000	20,8	14

4. Conclusion

The coastal areas in northern Vietnam (from Quang Ninh to Ninh Binh) has geological features, natural conditions vary by space and time.

According to the ability to prevent erosion, the study region is classified into five geographic areas. According to hydrodynamics, the study region is classified into two zones. Combining these results, together with the current status and erosion prediction study, the study area can be classified into five zones with different erosion characteristic.

Analysis of port exploitation, research region can be classified into two zones and two sub-zones. Zone I have the capacity to build large ports in the Cube Bay area, and other areas can only build small ports. Sub-zone IIA can build large ports, but the accretion process develops to the sea, so the port life is limited. Sub-zone IIB is not capable of building valuable ports.

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