



**PROCEEDINGS OF THE 4th INTERNATIONAL
CONFERENCE VIETGEO 2018**

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

Quang Binh, 21&22 September 2018

**INTERNATIONAL CONFERENCE
VIETGEO 2018**

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VIETGEO 2018

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**21&22 September 2018
QUANG BINH, VIETNAM**

Organized by

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Hanoi University of Mining and Geology (HUMG)
Quang Binh Department of Science and Technology
Technical World Co. Ltd (TW)
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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-construction 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</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
 <i>Residual shear strength of soil and its shear displacement rate dependency: an overview</i>	
<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 Diu, 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>Benjamin 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,</i>	

<i>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

PREFACE

Infrastructure development towards the sustainability in Vietnam as well as in the world is facing with many challenges, especially in the context of global climate change. Smart responses to climate change for harmonious and sustainable development are a legitimate desire. This is also the responsibility in the hands of scientists in general and geological - geotechnical engineers in particular.

Following the development and the success of the first conference in Hue 2012 (HueGeo 2012), the second in Hanoi in 2015 (HanoiGeo 2015), the third in Halong in 2016 (VietGeo 2016), the fourth international conference will be officially named VietGeo 2018. VietGeo 2018 is co-organized by the Vietnam Association of Engineering Geology and the Environment (VAEGE); Hanoi University of Mining and Geology (HUMG); Quang Binh Department of Science and Technology; Yamaguchi University, Japan; Suranaree University of Technology, Thailand; Tongji University, China; Ho Chi Minh University of Technology (HCMUT); VNU University of Science, Vietnam National University Hanoi (VNU-HUS); Hue University of Sciences - Hue University (HUSC); Hydraulic Construction Institute (HCI) and Technical World Co. Ltd (TW) on 21st and 22nd September 2018 in Dong Hoi city, Quang Binh province, Vietnam.

VietGeo 2018 will focus on the following themes:

- Slope stability and prediction,
- Coastal geotechnical engineering in response to climate change,
- Deep foundation and underground construction,
- Ground improvement method for infrastructure construction,
- Geotechnical instrumentation and materials.

VietGeo 2018 has received many kind supports from Quang Binh Department of Science and Technology, Technical World Co. Ltd (TW), FECON Corporation, GMC Investment and Development Co.Ltd. (GMC), Research Center for Technology and Industrial Equipment (RECTIE), Union of Survey and Construction J.S.C (USCO), Geotechnical Research Centre - HUMG, Nam Mien Trung Co. Ltd, Hanoi Construction Design Investigation Consultants J.S.C, Power Engineering Consulting J.S.C 1 (PECC1), Hydraulic Construction Institute (HyCI).

The organizing committee would like to express our sincere thanks and appreciations to all of participants and supporting institutions. Special thanks to members of the advisory board, local volunteers and especially those of the secretariats who handle the daily hard work to make the conference successful.

We hope you will find this conference not only a chance to discuss, to share experience but also to explore cooperative opportunities.

Organizing Committee of VIETGEO 2018

ESTABLISHING GEOLOGY ENGINEERING MAP OF THE HAI THINH AREA FOR PLANNING OF ECO-SOCIAL SUSTAINABLE DEVELOPMENT

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Abstract: Many geological, hydro-geological and engineering geological documents in Hai Tinh area have been researched. It can be based on these sources, combining geological study of additional works to establish engineering geological map at the scale of 1: 50,000. This article presents the results of research on engineering geological map of the 1: 50,000 scale in Hai Tinh area according to the proposed methodology of the International Association for Engineering Geology and UNESCO. Accordingly, the soil classification system (based on the principle of lithologic - origin) includes 7 lithological series, 17 lithological complexes and map annotation. The methodology was carried out by synthesizing and analyzing the collected data, identifying the characteristic zones (key zones), field trips, surveying, additional surveying at the key areas and areas with densely populated survey points, as a basis for stratigraphic relationships. Then, delineating the spatial boundaries between lithological series and lithological complexes in the system. split rock, from which establishing engineering geological map of 1: 50.000 scale.

Keywords: engineering geological map; Hai Tinh.

1. Introduction

According to the overall planning of socio-economic development up to the year of 2030 and approach to the year of 2050 in the north coastal plain of Viet Nam, Hai Tinh will become a key economic center. In order to serve the construction planning, socio-economic sustainable development, response to climate change and sea level rise, the establishment of engineering geological map (1: 50.000 scale) for this area becomes very necessary.

At present, geological map, engineering geological map and geo-hydrological map have been carried out with different scales in Hai Tinh and surrounding areas. In addition, there are many results of engineering geological surveying for specific projects. The amount of collected information increases day by day, focusing mainly on the factors of engineering geological conditions. In particular, characteristics of ground soil foundation and physico-mechanical properties of soils have been clarified. This is a very important

source, allowing the combined study of engineering geological conditions to map the engineering geological of 1: 50,000 scale, for planning, serving socio-economic sustainable development in the North Tonkin Gulf in general, Hai Tinh area in particular.

2. Choosing the method to establish engineering geological map of 1:50.000 scale

The engineering geological map can be established based on two principles: geological formation principle and engineering geological principle. Each principle has its own classification system in accordance with a unified principle, and the purpose of map (V.D. Lomtadze, 1983).

The principle of geological formation:

The orientation of engineering geological map is based on the analysis of geological formation and geological complex origin as a basis for dividing soils and rocks, then showing them on the map. According to G.K. Bondaric soils and rocks are divided into units from overall to detail as follows: geological formation → origin complexes

→ origin stratigraphic complexes → lithologic type → type → sub - type.

The advantage of this method is very general. Soils and rocks system reflects the common features and can be easily determined the geological conditions.

The disadvantage of this method is difficult to divide geological formation, geological complexes, and to express the engineering properties of soil.

The principle of engineering geological:

In this method, soils are divided according to the classification system already existed in the engineering geological. According to E.M. Xergeev, soils are divided into different units: Level → Group → Sub-group → Type → Form → Sub-form.

The advantage of this method, which can be used to solve the specific engineering geological problems. In addition, the map is clearly and easily in use.

By contrast, the disadvantage of this method is not high generality. Hence, it is difficult to predict the engineering geological properties of soil and other engineering geological factors.

Therefore, each method of establishing the map has its own advantages and disadvantages. According to the proposal of IAEG and UNESCO, it is possible to establish engineering geological maps based on the principle of lithological - origin. In this principle, the soil classification system is divided as follows:

- Lithological series: It consists of many lithological complexes which formed and existed in ancient geographic conditions, similar geotectonic (same origin);

- Lithological complexes: Including sets of lithological types have the same component and the same origin, formed and developed under specific ancient geography and tectonic conditions;

- Lithological types: Including soils, which has the same composition, texture, but not necessarily alike in physical state.

- Type of engineering geological (lithological species): Including homogeneous types of lithological characteristics and physical state.

It can be seen that the method of establishing the engineering geological map as proposed by IAEG and UNESCO is almost similar to the method of establishing the engineering geological map according to geological formation principle. However, according to the principle of lithological - origin of IAEG the soil classification system is simpler and presents the engineering geological properties of soils. It increases the advantages and decreases the disadvantages of the two methods and is very suitable for the purposes of establishing engineering geological maps for construction planning. On the other hand, in Vietnam, the procedure for establishment of the engineering geological map of 1: 50,000 scale (1: 25,000 scale) is proposed by Ministry of Industry in 2000, which based on classification of lithological- origin principle of IAEG and UNESCO. Therefore, it is very convenient for establishing engineering geological map at the scale of 1: 50,000 in this area.

3. Establishing engineering geological map of 1:50.000 scale in Hai Thinh area

3.1. Documentation

Documentations are used to establish engineering geological map in Hai Thinh area including:

- Topographic map at the scale of 1: 50,000;
- Geological map at the scale of 1: 50,000 (Le Tien Dung, 2015);
- Hydrological map at the scale of 1: 50,000 (Nguyen Van Lam [4] et al., 2015);
- Site investigation data, result of laboratory test and field test are taken from the engineering geological survey in this area (, from 1994 to 2015);
- Field researches document, supplementary engineering geological data;
- Additional investigation documents;
- Additional laboratory testing;
- Geological, geomorphic and neo-tectonic documents (Le Tien Dung, 2015), hydrological geology documents (Nguyen Van Lam [4], 2015), dynamic geological phenomena documents (Tran Huu Tuyen, 2015) and natural mineral and

materials for building (Tran Binh Chu, 2015) under the program of scientific and technological research of Ministry of Education and Training (code: CTB-2012-02).

3.2. Showing documentation on the map

The elements are presented on the engineering geological map including:

- Geological structure: including origin, age, lithological composition of rocks, bed rocks, folds, faults, distribution and thickness of primarily lithological complexes (lithological type);
- Topography: including elevation, terrain, mudflats, river terraces;
- Hydrological geology: including the sources, depth, chemical composition o, and corrosion characteristics of groundwater;
- Dynamic geological phenomena: including distribution and magnitude;
- Natural minerals and building materials: including location, distribution, and volume.

3.3. Map annotation

3.3.1. Soil classification system

According to the regulations for establishing engineering geology map of 1:50,000 scale (Ministry of Industry, 2000) and Vietnamese standard of soil classification TCVN 9362: 2012, in combination with Vietnamese standard TCVN 5747-1993, the classification system of soil on the

map includes: lithological series, lithological complexes and lithological types:

- Lithological series is the largest engineering geological unit on the map, including many lithological complexes which have the same origin.
- Lithological complexes is the smallest engineering geological unit on the map, consisting of lithological types which are similar in composition, origin and age;

Due to the complexity of sediment formation, in case of mixed soil origins (alluvial, marine and swampy deposit), the unit of lithological complexes is divided based on the origin and determination of the engineering geological characteristics of sediment mixture.

- Lithological types include soils of the same composition, texture, but not necessarily homogeneous in physical state. These types are not shown on the map, but their characteristics are described in the report. In the case of lithological complexes consist of only a lithological type, the lithological type will be shown.

In Hai Tinh area, there are 7 lithological series and 17 lithological complexes. (as shown in Table 1).

Tab. 1. The soil classification system and its characteristics in Hai Tinh area

Lithological series	Main lithological complexes – Lithological types
1- Alluvial (a)	1- $aQ_2^3tb_3$: clayey sand, soft to firm
	2- $aQ_1^{2-3}hn$: fine sand, dense to very dense
	3- $mQ_2^3tb_3$: fine sand, loose
	4- $mQ_2^3tb_2$: clayey sand, soft
2- Marine (m)	5- $mQ_2^3tb_2$: clayey sand, soft
	6- $mQ_2^{1-2}hh_2$: clay, soft to firm
	7- mQ_1^3vp : clay, firm to medium stiff
	8- $amQ_2^3tb_3$: clayey sand, soft
	9- $amQ_2^3tb_2$: clay, soft to firm
3- Fluvial - marine (am)	10- $amQ_2^{1-2}hh_1$: clayey sand, soft
	11- amQ_1^3vp : clayey sand, medium firm
	12- $amQ_1^{2-3}hn$: sandy clay, medium stiff
	13- amQ_1^1lc : sand with gravel, dense to very dense
4- Marine – wind (mv)	14- $mvQ_2^3tb_3$: fine sand, loose to very loose

5- fluvial – marine - swamp (amb)	15- ambQ ₂ ³ tb ₂ : clayey sand mud
6- Marine - swamp (mb)	16- mbQ ₂ ¹⁻² hh ₁ : clayey mud
7- Terrigenous sediment (N ₂ vb)	17- N ₂ vb: gravelstone

3.3.2. Presenting the soil classification system and the engineering geological factors on the map

The soil classification system:

* Lithological origin series are presented by color and symbol principle of origin (as specified

on the geological map):

+ Quaternary sediments:

- Fluvial origin: bluish;

- Marine origin: bluish;

- Swampy origin: bright grey;

- Windy origin: light yellow.

In the case of a mixed-lithological series, a mixture of colors is used, in which the main color is the lithological series that predominates in origin and thickness.

+ Early Quaternary formation: terrigenous sediments origin has light purple color.

* Lithological complexes (lithological types) are represented by lithological symbols of the main lithological type as defined on the geological map:

- The composition of the main lithological type of the first lithological complex (exposed on the ground) is represented by orange color;

- The composition of the main lithological type of the first lithological complex (below the first complex) is represented by gray color;

- The thickness of the first lithological complex (lithological type) is represented by the symbol of the main lithological type in different directions, with the divisions: less than 2m; 2 to 5m; 5 to 10m and above 10m. The thickness of the second lithological complex is not shown on the map;

The boundary of the first lithological complex is shown by black lines. If it has different thicknesses, it is represented by black dashed lines;

The boundary of the second lithological

complex is represented by black horizontal lines

The stratigraphic order within the depth of study is expressed by fractions of the origin, age of the lithological complex, in order from the top to down;

Stratigraphic factors, tectonics are represented similarly to those in geological maps;

Hydrological factors are represented by blue conventional symbols which are similar to those in the hydrogeological maps;

Dynamic geological phenomena are represented by red symbols, not to scale;

Natural minerals and building materials are represented by black conventional symbols;

Exploration works, field tests are expressed by black symbols;

Other factors are represented by black lines.

3.3.3. Map annotation content

The annotation of engineering geological map at the scale of 1: 50,000 was established based on the soil classification system and shown on the map (Table 2).

3.4. Method of establishing engineering geological map

To establishing a 1: 50,000 scale engineering geological map of Hai Tinh area, the geological, hydrological and engineering geological data are synthesized and analyzed, in combination with additional field work. The process is as follows:

+ Collecting data such as engineering geological map, engineering geological zoning map at the scale of 1:200.000 of Hai Phong and Nam Dinh area, geomorphological map, geological map, hydrology geological map at the scale of 1:50.000 of Hai Tinh area and the engineering geological survey data are collected in Hai Tinh. The number of collected data is as follows:

- Number of construction: 83;

- Number of boreholes: 262;

- Total depth of boreholes: 7.324m

- Average distance between engineering geological survey sites: 790m.

- Average distance between boreholes: 360m
 - Number of samples: 1.678
 - Number of field tests (standard penetration test-SPT), vane shear test -VST):1.215 points
 - + Based on the same scale of geological map and the collected data, studying the engineering geological conditions in the area, identifying the key zones are used as the basis for field works.
 - + Organizing the field trip, supplementary measurement, paying attention to the key zones and the area in which the collected data are not suitable for the standard density of establishing engineering geological map at the scale of 1:50.000 (1 to 3 engineering geological survey sites per square kilometer). Contents of this study include:
 - Topographic, geomorphology factors;
 - Characteristics of geological structure, weathering and their relationships with dynamic geological phenomena;
 - Observation, detailed description of soil and rock at the sites, identification of characteristics, composition, color, state, and texture of soil and rock in laboratory.
 - Characteristics of aquifers, groundwater levels, fluctuation of groundwater, influence of groundwater on the state and properties of soil and rock;
 - Identifying the distribution, characteristics of factors which affect the development of dynamic geological phenomena; their impacts on constructions and environment;
 - Identifying the types, the characteristics, and the distribution of natural materials for building purposes.
- In the field study, it is necessary to pay attention to the distribution rules, the change rules of the engineering geological conditions factors, as a basis for connecting, determining the general engineering geological conditions in this area.

Tab. 2. The annotation of engineering geological map of the 1: 50.000 scale in Hai Tinh area

Lithological series	Lithological complex				Second layer	Soil description	
	Geological age	Thickness of the first layer (m)					
		< 2	2 - 5	5 - 10	> 10		
Fluvial	aQ ₂ ³ tb ₃					Clayey sand (soft to firm), silty sand (loose), brownish grey, light yellow	
	aQ ₁ ²⁻³ hn		only appears on the section				Fine sand, coarse sand with gravel, sandwiched clayey sand, grey, brownish grey (dense to very dense)
	mQ ₂ ³ tb ₃					Fine sand (loose), clayey sand (soft to firm), bearing seashells, grey, brownish grey	
Marine	mQ ₂ ³ tb ₂					Clayey sand (soft), fine sand (loose), brown, yellowish grey, brownish grey	
	mQ ₂ ³ tb ₁					Clayey sand sandwiched fine sand, bearing little organic, brownish grey, grey (soft)	
	mQ ₂ ¹⁻² hh ₂					Clay, clayey sand sandwiched fine sand, greenish grey, grey (soft to firm)	
	mQ ₁ ³ vp		only appears on the section				Clay, clayey sand, yellowish grey, bright grey, greenish grey (medium stiff to firm)
	amQ ₂ ³ tb ₃						Clayey sand, clay, bearing sand, sandy clay, brownish grey, darkish grey (soft)
	amQ ₂ ³ tb ₂						Clay, clayey sand, bearing sand, yellowish grey, light yellow (soft to firm)
Fluvial - Marine	amQ ₂ ¹⁻² hh ₁		only appears on the section				Clayey sand, clay, bearing sand, organic, seashells, darkish grey (soft)
Fluvial - marine - swampy	amQ ₁ ³ vp		only appears on the section				Clayey sand, clay, bearing sand, brownish grey, yellowish brown (medium stiff)
	amQ ₁ ²⁻³ hn		only appears on the section				Sandy clay (medium stiff), clayey sand, bearing sand brownish grey, light grey (medium stiff to firm)
	amQ ₁ ¹ lc		only appears on the section				Sandy clay, bearing gravel, small cobble, brownish grey, darkish grey (dense to very dense)
	mv						Fine sand, silty sand, brown, yellowish grey, brownish grey (loose to very loose)
	ambQ ₂ ³ tb ₂						Clayey sand mud, sandy clay mud with seashells, brownish grey, darkish grey
Terrigenous sediment	mbQ ₂ ¹⁻² hh ₁		only appears on the section				Clay mud sandwiched little fine sand, bearing organic, brownish grey, darkish grey
	N ₂ vb		only appears on the section				Gravel stone, sandstone, silty sandstone, claystone and brownish peat lens

Surveying engineering geological, field testing, laboratory testing at the key zones. The number of additional studies, the survey results in this area are shown in Table 3.

The studying at the key zones allows to identification of stratigraphy, physico-mechanical properties, and lithological - sediments characteristics of geological formations. Then,

determining the composition, state, color, physico-mechanical properties of each lithological complex (lithological type), determining the layers that has the distinctive features of the upper and lower sediment layers. This work which is the basis for the stratigraphic identification, delineation of spatial boundaries (by area and depth) among the mapping units. Stratigraphy is represented at each key zone in this area as shown in Table 4.

Tab. 3. Number of engineering geological survey in the key zones

Key zone	Engineering geological exploration		Laboratory test (sample)		Field test (point)	
	Number (borehole)	Total boreholes length (m)	Normal properties	Special properties	SPT	VST
Hai Chinh 1	6	142	24	-	41	28
Hai Chinh 2	14	317	99	3	158	30
Hai Ninh	13	190	63	-	95	24
Truc Phu 1	8	275	60	-	90	-
Truc Phu 2	5	162	25	-	30	19

Tab. 4. Main stratigraphy at researching zones

Key Zone	Lithological complex	Depth (m)		Soil description
		From	To	
Hai Chinh 1	amQ ₂ ³ tb ₃	0.0	8.0	Clayey sand with organic, darkish brown, brownish grey, soft
	amQ ₂ ³ tb ₂	8.0	16.0	Sandy clay bearing organic, brownish grey, yellowish grey, firm
	mQ ₂ ¹⁻² hh ₂	16.0	>25	Clay, brownish grey, light grey, firm
Hai Chinh 2	ambQ ₂₃ tb ₃	0.0	4.2	Clayey sand mud, darkish grey, brownish grey
	amQ ₂ ³ tb ₂	4.2	24.5	Clay, brownish grey, firm
	mQ ₂ ¹⁻² hh ₂	24.5	29.5	Clay, whitish grey, firm
	amQ ₂ ³ vp	29.5	>34	Clayey sand, light brown, medium stiff
	amQ ₂ ³ tb ₃	0.0	5.2	Fine sand, yellowish grey, grey, loose
Hai Ninh	mQ ₂ ¹⁻² hh ₂	5.2	36.0	Clayey sand sandwiched sandy clay, grey, darkish grey, firm
	amQ ₂ ¹⁻² hh ₁	36.0	45.0	Sandy clay, grey, darkish grey, firm
	amQ ₁ ³ vp	45.0	93.0	Clayey sand, grey, reddish brown, medium stiff
	aQ ₁ ²⁻³ hn	93.0	>98	Coarse sand with gravel, greenish grey, whitish grey, medium dense
Truc Phu 1	mQ ₂ ³ tb ₃	0.0	4.0	Clayey sand, grey, brownish grey, firm
	mQ ₂ ³ tb ₂	4.0	10.0	Clayey sand, grey, light yellow, soft
	mQ ₂ ³ tb ₁	10.0	15.0	Clayey sand, brownish grey, darkish grey, soft
	mQ ₂ ¹⁻² hh ₂	15.0	27.0	Clay, greenish grey, soft to firm
	mQ ₂ ¹⁻² hh ₁	27.0	43.0	Clayey sand, grey, firm
	mQ ₁ ³ vp	43.0	50.0	Clayey sand, yellowish grey, greenish grey, firm to medium stiff
	amQ ₁ ³ vp	50.0	70.0	Clayey sand, brownish grey, yellowish grey, reddish grey, medium stiff
	amQ ₁ ²⁻³ hn	70.0	>80	Clayey sand, brownish grey, light grey, firm to medium stiff
Truc Phu 2	amQ ₂ ³ tb ₃	0.0	4.0	Clay, brown, soft to firm
	amQ ₂ ³ tb ₂	4.0	14.0	Clayey sand, brownish grey, darkish grey, soft
	mQ ₂ ¹⁻² hh ₂	14.0	>25	Clay, greenish grey, brownish grey, firm

On the basis of geological maps with the same scale and supplementary research data, stratigraphy at the key zones, the accuracy of the existing engineering geological data, stratigraphic links, origin of lithological complexes in this area that determine the spatial boundaries (shown on the map and in depth - shown on the section) with the soil units system in the study area. Then, expressing them together with other engineering geological factors such as geomorphology, geological structure, hydrogeology, dynamic geological phenomena and natural mineral materials for building on the map.

4. Conclusions

The research results allow to draw some conclusions:

- Soil classification base on the lithology - origin principle of IAEG and UNESCO is the appropriate method for establishing engineering geological map at the scale of 1: 50,000 for construction planning, socio-economic sustainable development in the North coastal plain;

- According to the principle of lithology - origin, the soil classification system of the engineering geological mapping at the scale of 1: 50,000 of Hai Thinh area is divided into 7 lithological series (m, mv, mb, a, amb, am, N₂vb) and 17 lithological complexes (mQ₂³tb₃, mQ₂³tb₂, mQ₂³tb₁, mQ₂¹⁻²hh₂, mQ₁³vp; mvQ₂³tb₃; mbQ₂¹⁻²hh₁; aQ₂³tb₃, aQ₁²⁻³hn; ambQ₂³tb₃; amQ₂³tb₃, amQ₂³tb₂, amQ₂¹⁻²hh₁, amQ₁³vp, amQ₁²⁻³hn, amQ₁¹lc; N₂vb);

- To establish engineering geological map at the scale of 1: 50,000, of Hai Thinh area, the "key zone" can be used on the basic of collected geological and hydro-geological documents and the engineering geological survey documents from the existing construction in this area, combined with the additional engineering geological research to set up database mapping.

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