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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QUANG BINH, VIETNAM

Organized by

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Hanoi University of Mining and Geology (HUMG)
Quang Binh Department of Science and Technology
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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 Cenre - 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 Thinh 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 Thinh 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 Thinh.

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 Thinh 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 Thinh 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 Thinh 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 geo-tectonic (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 Thinh 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 Thinh area

Lithological series	Main litholigical complexes – Litholigical 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- am $Q_2^3tb_2$: 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 - swapm (amb)	15- $amb Q_2^3 tb_2$: clayey sand mud
6- Marine - swamp (mb)	16- $mb Q_2^{1-2} hh_1$: clayey mud
7- Terrigenous sediment (N2vb)	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 above10m. 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 Thinh 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 Thinh area and the engineering geological survey data are collected in Hai Thinh. 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.

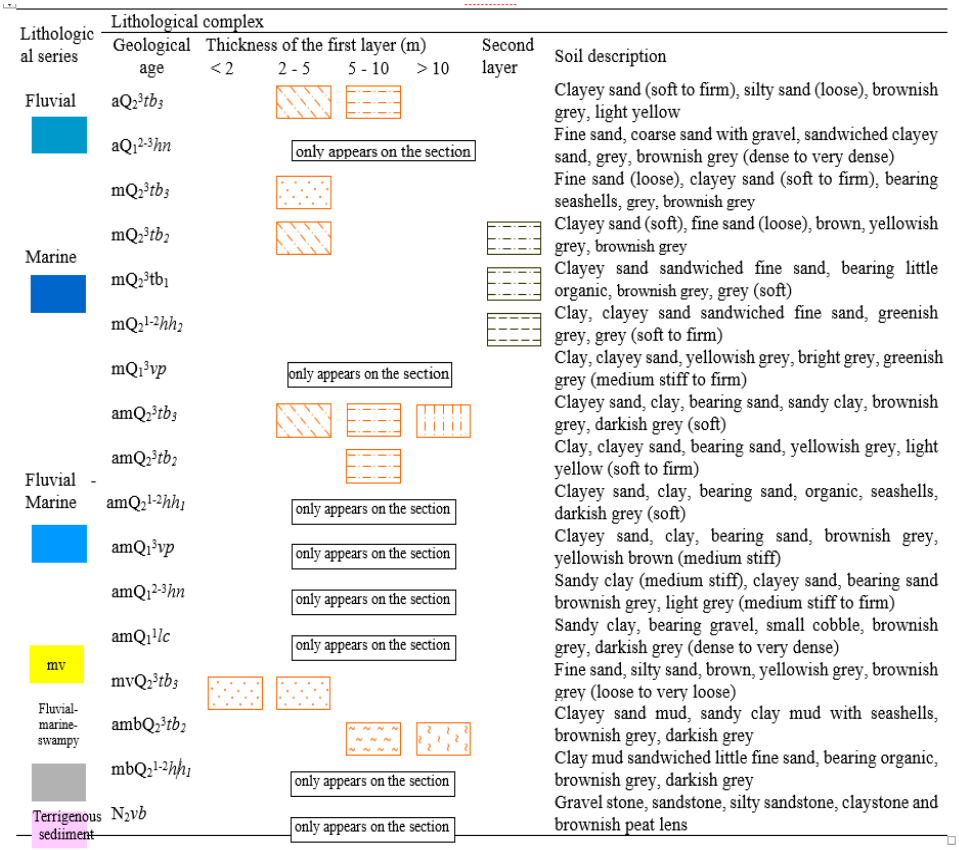
- Characteristics of aquifers, groundwater levels, fluctuation of groundwater, influence of groundwater on the state and properties of soil and rock;

- 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 Thinh area



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	$amQ_2^3tb_3$	0.0	8.0	Clayey sand with organic, darkish brown, brownish grey, soft
	$amQ_2^3tb_2$	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
	$amQ_2^3tb_2$	4.2	24.5	Clay, brownish grey, firm
	$mQ_2^{1-2}hh_2$	24.5	29.5	Clay, whitish grey, firm
	amQ_2^3vp	29.5	>34	Clayey sand, light brown, medium stiff
Hai Ninh	$amQ_2^3tb_3$	0.0	5.2	Fine sand, yellowish grey, grey, loose
	$mQ_2^{1-2}hh_2$	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_1^3vp	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	$mQ_2^3tb_3$	0.0	4.0	Clayey sand, grey, brownish grey, firm
	$mQ_2^3tb_2$	4.0	10.0	Clayey sand, grey, light yellow, soft
	$mQ_2^3tb_1$	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_1^3vp	43.0	50.0	Clayey sand, yellowish grey, greenish grey, firm to medium stiff
	amQ_1^3vp	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	$amQ_2^3tb_3$	0.0	4.0	Clay, brown, soft to firm
	$amQ_2^3tb_2$	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, N_2vb) and 17 lithological complexes (mQ_2^3tb3, mQ_2^3tb2, mQ_2^3tb1, mQ_2^{1-2} hh2, mQ_1^3vp; mvQ_2^3tb3; mbQ_2^{1-2}hh1; aQ_2^3tb3, aQ_1^{2-3}hn; $ambQ_2^3$tb3; amQ_2^3tb3, amQ_2^3tb2, amQ_2^{1-2} hh1, amQ_1^3vp, amQ_1^{2-3}hn, amQ_1^1lc; N_2vb);

- 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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