ENGINEERING GEOLOGICAL PROBLEMS IN IMPLEMENTING DEEP EXCAVATIONS IN HUE CITY AREA

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ABSTRACT: With a view to realize the 48th conclusion of Political Bureau of the KPV on early construction and making Thua Thien - Hue to become a city directly under the central government, the expansion and speeding up urbanization of the province in general and planning the low and medium building with basement in the opinion of saving fund of land, preserving the city of tangible and intangible cultural heritage in particular have become current focus works of Thua Thien - Hue. Beauty of a tourist city is keft and maitained a sustainable development based on the harmonious combination between natural, environmental and economic - social conditions and long-term stability of the buildings. Therefore, this paper tries to indicate the engineering geological problems in implementing deep excavations in various types of the typical foundation structures widely distributed in Hue city.

OVERVIEW OF DEEP EXCAVATION

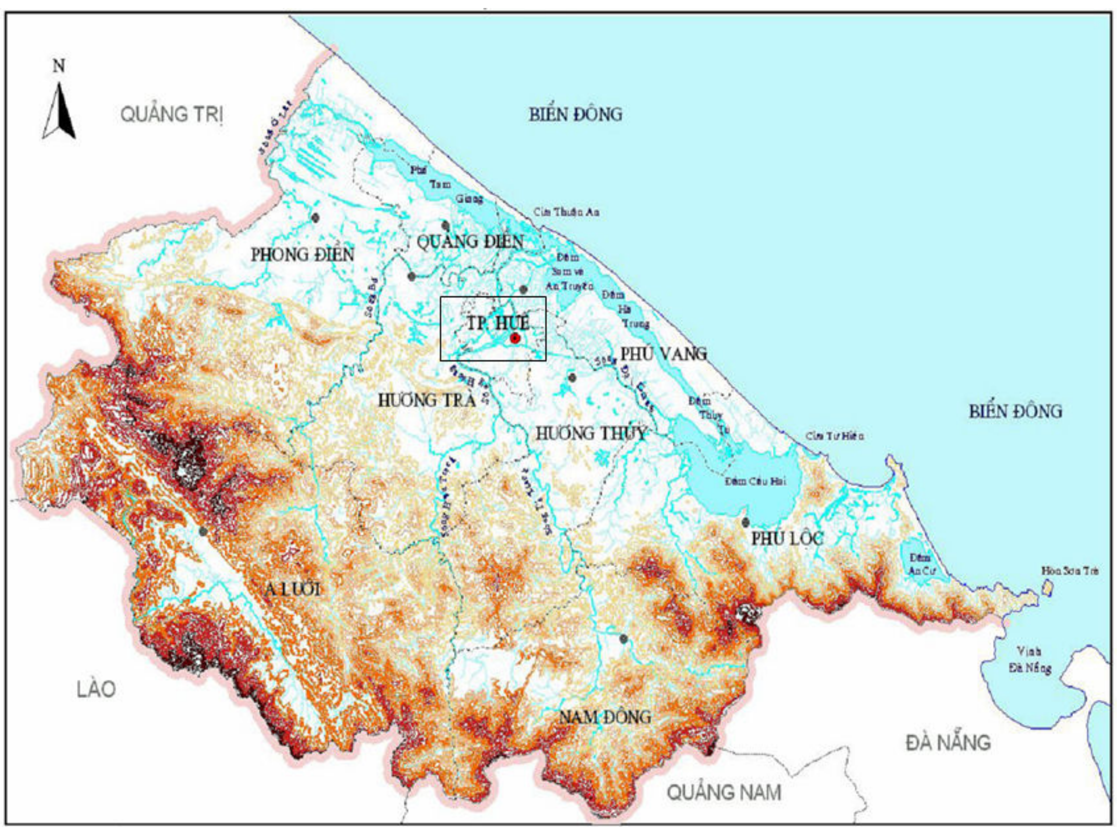


Figure 1 Location of the study area in Thua Thien Hue province

With the current tendency of strong development on construction, building land is more and more narrowed gradually. Thus, to save funds and to fully exploit the land, the ideas of using the underground space for many different purposes of economy, society, culture, environment, even the military defense, etc. are carried out. Most developed countries have proposed the rules on building high constructions with basement (using deep excavation) such as: Tokyo (Japan), Shanghai (China), Moscow (Russia), Geneva (Switzerland), Ho Chi Minh and Ha Noi (Vietnam), etc..

In recent years, in major cities of our country, there are too many incidents of works (settlement, collapse, drop, etc.) during implementing of deep excavation. In particular, the engineering geological problems such as settlement, slide, cracked bottom of excavation, etc. are the causes of these incidents. There has not been a shortage of building land yet in Hue city, however, to construct the modern city, but still keep ancient characters of ancient former capital on sustainable development perspective, the works of planning and construction of low to moderate level building that have basement are a problem which should be kept in mind while striving to build Hue city soon to become a central one in the future. Thus, in order to meet the demand for land for construction in Hue city on land-saving perspective, the research on engineering geological problems and the propose of stable, effective solutions for scientific basis for survey, fast oriented design in the planning, sustainable development of this city are very urgent. It is not only scientifically significant, but also high applicable in the development stage today (Figure 1).

In fact, the use of glossary “deep excavation” has existed for a long time [3], [4], [5], but until now this concept is still unclear. However, we can understand that the buildings with deep excavation are often high-rise with a section of works placed under the ground (the basement). Thus, one must dig the excavation to the depth designed to create an underground space in accordance with purposes of use. In which, the excavations of over 5 meters deep are considered deep excavations. Excavations which are fewer 5 meters but complicated in engineering geological conditions must also be dealt with as deep excavation. To evaluate and forecast the engineering geological problems related to deep excavation, we have divided the structures of foundation in Hue area into some types as follows

TYPES OF GROUND STRUCTURES IN HUE CITY

Many authors have argued and given their viewpoints on ground structure of buildings for many years (Nguyen Thanh, 1984; Vu Cao Minh, 1984; Le Trong Thang, 1991; Nguyen Ba Hoang, 2001...). However, it is not certainly easy to have a final concept or define an issue that is much discussed. In our opinion, the ground structure is the interaction between construction and geological environment, and characterized by rules of the distribution with depth, the ability to change with time of soil components with origin, age, composition, structure, thickness, state, and engineering geological characteristics determined. The rule of distribution with depth of the soil components reflects the relationship of their stratigraphy and the history of the natural process of formation of rocks. Areas affected by construction are understood as the limit at which the rock formation impacts directly to the building. For the ground structure of “soft soil” layers, the depth of research must cover the thickness of these layers and be deeper than the depth of the area of influence. It is possible to understand that the ground structure of soft soil is the type directly related to soft soil formation. Soft soil plays a main and meaningful role to decide the characteristics and building capabilities of the ground structures. The composition, property, thickness, variation of soft soil in space and the relationship between them and different types of soil are very significant for the characteristics and building capabilities of its ground structure. Besides, the location of the ground structure of soft soil in geological environment is also important. Indeed, with the same type of soft soil structure, the same feature of scale and building structure, the ability of deformation of building will be very different depending on the amplitude of underground water drawing along with the directions of change on engineering geological features of ground structure. Thus, the influence of geological environment to the ground structure of soft soil and to the building depends on specific conditions of their existence. Therefore, the typical range of distribution, types, and forms of the ground structure will help planners rationally arrange the construction works. For each type of ground structure, there are many methods of survey, methods of forecasting the change of geological environment and the rational use of diagrams, various ways of territorial protection to help investigators, designers to determine the correct method and level of survey, scale and structure type of building, the foundation design and background processing, to select diagram(s) for calculation bearing capacity as well as the expected deformation of ground during construction and exploitation period from the beginning.

From the above viewpoint on the ground structure, it is possible to establish the level of the ground structure according to the following criteria (Figure 2):

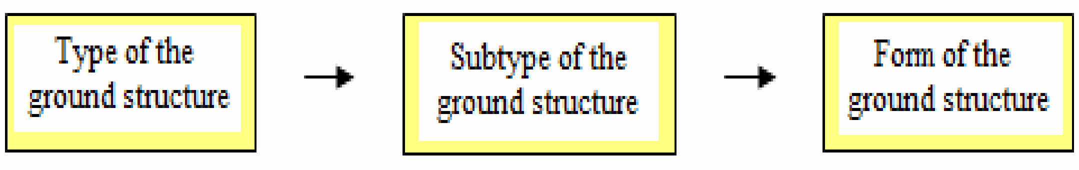


Figure 2 Diagram of establishing the level of the ground structure for construction.

Among them, the ground structure is divided under the feature of architectural link between the particles, crystal forming soil – rock located in areas affected by the project (25m) and is marked by Roman numerals I, II and III. The subtype of ground structure is separated from the type based on the identical level of the assemblage of lithological types in vertical direction and is marked by the uppercase letters A, B and C. Forms of structure are divided from the above subtypes on the basis of considering the thickness of soft soil. Here, we only divided forms from the subtypes of the ground structure in which the soft soil is involved. The form of ground structure is often marked by lowercase letters a, b and c. According to the above principle of division, the ground structure of survey area can be divided into 3 types, 4 subtypes and 3 forms as follows [6], [7] (Pham Thi Thao, 2004).

Type I: The ground structure is composed of soil-rock without rigid bond (Quaternary sediments). This type includes 2 subtypes (IA, IB)

+ Subtype IA: The ground structure is made up from soil-rock without rigid bond and with the appearance of soft soil. This subtype is divided into 2 forms as IAa and IAb.

Form IAa: It is composed of soil-rock without rigid bond and with soft soil of more than 6 meters thick.

Form IAb: It is composed of soil-rock without rigid bond and with soft soil of fewer than 6 meters thick.

+ Subtype IB: This structure is constituted of soil-rock without rigid bond and soft soil.

*Type II***:** This type is composed of 2 lithological assemblages as the Quaternary sediment covering formation with rigid bond (bedrock). This type includes 2 subtypes (IIA and IIB):

+ Subtype IIA: This subtype is composed of 2 lithological assemblages as the Quaternary sedimen

with the appearance of soft soil covering bedrock. This subtype just divides into a form IIAb

Form IIAb: It is made up from 2 lithological assemblages as the Quaternary sediment with the soft soil covering bedrock of fewer than 6 meters thick.

+ Subtype IIB: This subtype is constituted of 2 lithological assemblages as the Quaternary sediment without soft soil covering bedrock.

Type III: The ground structure is made up from soil-rock with rigid bond (bedrock).

The specific structures and physical – mechanical properties of the rocks of Hue city area are shown by the diagram of zoning of Figure 3, Table 1 and Table 2.

On the basis of the divided ground structure, we have conducted the audit of engineering geological problems that can arise for deep excavation in 3 meters, 6 meters, 9 meters respectively in the following

FORECASTING FOR ENGINEERING GEOLOGICAL PROBLEMS ARISING DURING IMPLEMENTING DEEP EXCAVATION IN GROUND STRUCTURE OF THE SURVEY AREA

For the study area, when excavation is executed at a depth of 3 meters, 6 meters, 9 meters respectively, the engineering geological problems as [2], [3], [4], and [5] can be arisen:

- Emergence of the bottom of excavation: This problem usually results from decompression during dig the excavation and the loss of pressure makes the cohesive soil at the bottom of the foundation with its strong bulking to dilate and increase gradually its volume, then causing the emergence of the bottom of excavation. This phenomenon can occur slowly or quickly depending on the mineral composition and degree of bulking of clay, the period of time for implementing excavation as well as the level of reduced pressure. According to Terzaghi - Peck [3], when the internal angle of friction $\varphi = 0$ (soft clay) and sliding surface is curved or flat, the soil on either side of excavation wall (which create pressure effects) like super load which distributes evenly and affects the cross section makes the bottom of excavation bend. If the bottom of excavation is clay with strong bulking, it will accelerate the process of bending the soil in the bottom of excavation (Figure 4).

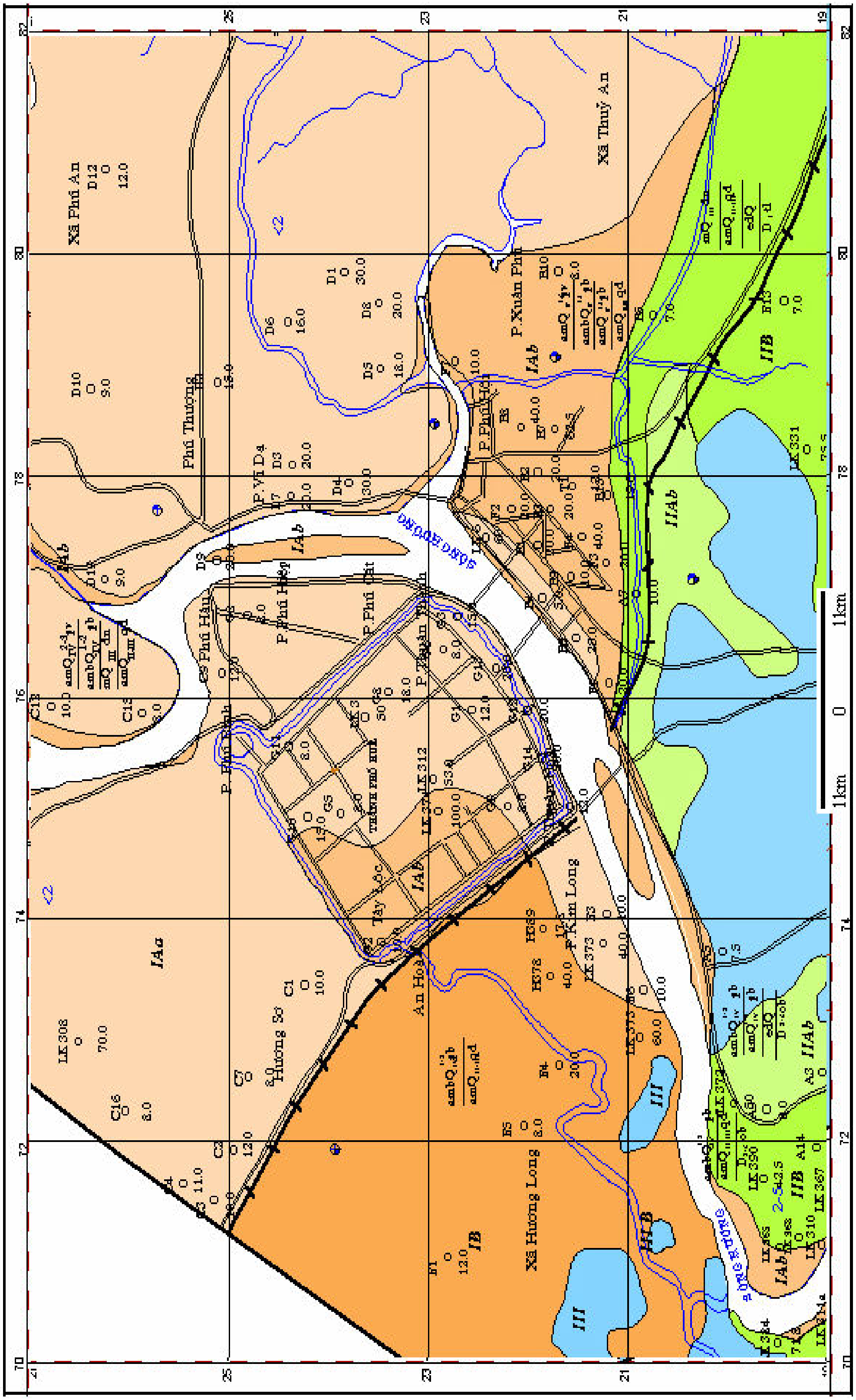


Figure 3 Zoning layout of the ground structure of Hue city area.

Table 1 The explanation of ground structure zoning of Hue city area.

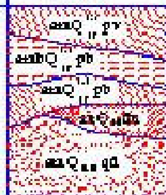
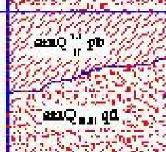
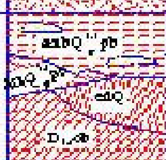
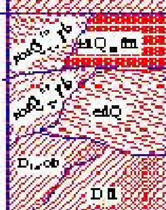
Type	Sub type	Form	Columnar section	Depth (m) min - max	Topography	Geological structures	Hydrogeological feature	Physical - mechanical property
I	IA	IAa		0.8-13.1; 6.5-23.0; 1.6-8.6; 3.6-7.6; 24.0-43.0	Low plain and agglomerate plain, rare flood	Formations such as Phu vang, Phu Bai, Quang Dien alternating Da Nang one somewhere. Soft soil of Phu Bai- Quang Dien formation: combined river-sea-swamp origin and combined river-sea origin. Composition : clayey mud, organic muddy loam, fine sand running shell. > 6m thick	2 aquifers including Holocene, Pleistocene. Mean water abundance. Level of water: < 20 meters in depth. Corrosive water of CO2, HCO3.	Phu Vang sediment: soft plastic, mean strength and compressibility. Soft soil of Phu Bai sediment: high humid, liquid - liquid plastic, low strength, high compressibility. Da Nang sediment: high dense, fairly good bearing capacity. Quang Dien sediment: humid, strength, deformation varing on a large scale.
		IAb		1.5-5.0; 1.7-8.7; 2.0-5.0; 2.0-22.9; 2.0-40.0	Relative low plain, agglomerate battures, not flooded	Formation such as Phu Vang, Phu Bai, Quang Dien alternating Da Nang one somewhere. Soft soil of Phu Bai: clayey mua, organnic muddy loam, fine sand running shell. < 6m thick	Including Holocene and Pleistocene aquifers. Pleistocene aquifer locates deep, weak waterproof roof. Level of water: <20m. Corrosive water for CO2, HCO3	Phu Vang sediment: soft plastic, mean strength and compressibility. Phu Bai formation: high humid, liquid-liquid plasric, low strength, high compressibility. Da Nang sediment: high dense, good bearing capacity. Quang Dien sediment: low humid, relative stability.
	IB			1.6-12.0; 5.6-19.6	Distributing at plain of Huong Long - Huong An area, not flooded	Absence of Phu Vang formation. Phu Bai formation covers Quang Dien one in unconformity. No soft soil	Including Holocene and Pleistocene aquifers. Level of water: <20m. Corrosive water for CO2	Phu Bai sediment: comnined river-sea origin, bearing capacity from mean to fairly good. Quang Dien sediment: sandy loam, loam running grit, high strength, small deformation.
II	IIA	IIAb		7.3-12.0; 2.0-23; 2.5-5.0; 15.0-40.0	Fairly high topography distributes at Thuy Bieu, Long Tho	Phu Bai formation exposing on surface with combined sea-swamp origin. Composition os soft soil: muddy loam running botanical humus, sandy loam running shell and mean sand alternating thin layer of sandy loam. 20m thick	Level of water: 2 - 5m. Corrosive water for CO2, HCO3	More deeper it is, more higher the deformation of Phu Bai sediment becomes. Rock of Co Bai formation is fairly good for construction's ground.
	IIB			2.5-5.0; 1.5-4.0; 15-60; 150-200	Fairly high topogaraphy being transition place between mountain and plain	Phu Bai, Da Nang formation expose on surface. Quang Dien sediment often run grit. Rock of Co Bai, Devon formations are under the eluvium. No soft soil.	Level water: 2.5m, even >5m. Confined aquifer appears somewhere in depth.	Da Nang and Quang Dien sediments: low humid, high strength, small deformation. Rock of Tan Lam, Co Bai formation can satisfy needs on ground with every scales
III				0.5-5.0; 150-200; 500-2700	High knob-and-kettle topography	edQ sediment covers surface, somewhere bedrock exposes on surface	No water. Poor aquifer is somewhere with level of water more than 5m.	Good building capacity. Gully, landslide, ect need to be noticed.

Table 2 The physical – mechanical properties of the Quaternary sediment at Hue area

Formation	Grain-size					Humid	Plastic index	Viscosity	Natural density	Dry density	Specific density	Void ratio	Saturation degree	Cohesion	Internal friction angle	Compressive coefficient	Total deformation modulus
	Cobble	Gravel	Sand	Silt	Clay												
	>20	20-2.0	2.0-0.05	0.05-0.005	<0.005	W (%)	I_p (%)	B	$\square_w$ (g/cm^3)	$\square_c$ (g/cm^3)	Δ (g/cm^3)	e_o	G (%)	C (kG/cm^2)	□ (degree)	a_{1-2} (cm^2/kG)	E_{1-2} (kG/cm^2)
$amQ_1^{2-3}q$®	Grey medium sand running gravel.																
	2.3	13.4	84.3			25.3			1.92	1.53	2.65	0.730	91.9		28^{o}31	0.02	72.1
	Yellow grey running white grey fine sand																
			100			20.2			1.92	1.65	2.65	0.610	87.9		18^{o}24	0.02	95.6
	Ashy grey running black loam, liquid plastic state																
			13.9	51.8	34.3	39.4	16.6	0.75	1.82	1.31	2.70	1.046	98.8	0.105	6^{o}25	0.09	27.6
	Grit soil																
		42.4	57.6			14.2			1.99	1.74	2.66	0.520	72.3			0.01	122.9
mQ_1^3®n	Bright yellow running brown, white grey sandy loam																
		4.1	62.1	27.4	6.4	19.5	5.4	0.35	2.07	1.71	2.66	0.540	93.5	0.152	14^{o}18	0.016	86.05
	Bright yellow – white grey running brown loam running grit, stiff plastic																
		22.5	31.8	34.1	11.6	20.8	10.3	0.29	2.07	1.71	2.69	0.564	98.8	0.170	17^{o}38	0.010	151.2
$amQ_2^{1-2}pb$	White running yellow – red loam, semi-stiff																
			46.0	30.0	24.0	18.0	16.9	0.15	2.05	1.74	2.70	0.55	87.7	0.08	14^{o}43	0.02	66.5
	Yellow grey – white grey silt loam, stiff plastic																
		0.3	19.7	51.5	28.5	20.3	16.9	0.32	2.05	1.70	2.71	0.60	92.6	0.095	15^{o}11	0.02	61.1
	Blue grey – black grey loam running grit, soft plastic																
		6.1	30.3	50.3	13.3	30.2	12.4	0.68	1.83	1.41	2.70	0.780	99.3	0.06	7^{o}20	0.037	56.6
$ambQ_2^{1-2}pb$	Black grey muddy sandy loam running shell, organic material, plastic – soft																
			59.0	34.5	6.5	43.4	5.3	0.83	1.67	1.16	2.67	1.29	89.6	0.09	9^{o}56	0.07	21.7
	Black grey medium sand running shell																
		2.7	97.3			19.6			1.91	1.60	2.64					0.02	71.5

$ambQ_2^{1-2}pb$	Black grey - blue grey muddy clay running shell, liquid																
		0.8	13.7	33.3	52.2	58.0	23.1	1.13	1.61	1.02	2.67	1.51	98.7	0.02	5^o18	0.137	18.2
	Black grey - blue grey muddy loam running shell, liquid																
			19.7	65.2	15.0	52.4	16.3	1.04	1.63	1.01	2.66	1.52	94.7	0.05	6^o29	0.114	15.5
$amQ_2^{2-3}pv$	White grey – Blue grey loam, soft plastic																
		0.2	24.9	53.0	21.9	29.0	15.6	0.65	1.87	1.51	2.70	0.80	93.5	0.15	8^o44	0.032	55.8
	Yellow grey clay, soft plastic																
		0.1	16.7	51.4	31.8	25.4	17.7	0.57	1.93	1.53	2.72	0.78	91.3	0.09	14^o43	0.02	70.5
	White running yellow silky sand, medium dense																
			100.0			24.2			1.99	1.60	2.66	0.66	97.5	0.08	17^o30	0.04	87.7
	Blue grey – yellow grey running red sandy loam, plastic																
			74.0	18.0	8.0	28.4			1.89	1.47	2.67	0.81	93.2	0.11	26^o07	0.03	65.0
aQ_2^3	Yellow grey sandy loam, plastic																
			70.5	24.5	5.0	21.4	4.5	0.53	1.93	1.59	2.67	0.68	84.1	0.11	12^o21	0.035	46.1
	Yellow grey sand, soft																
		1.0	99.0						1.85	1.47	2.65	0.80	85.2	0.00	29^o50	0.035	50.6
edQ	Compositing of grit – yellow brown – red brown loam																
		14.7	37.0	36.7	11.6	19.5	14.1	0.23	2.03	1.68	2.67	0.62	91.3	0.17	18^o38	0.018	164.0

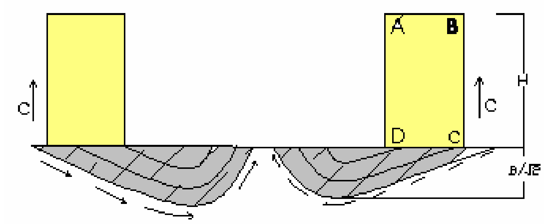


Figure 4 Audit diagram on the emergence problem at the bottom of excavation in the depth of H

From Figure 4, Terzaghi has supposed that cohesion C on the side BC and the entire load P on CD is determined as formula 1

$$P = \frac{B}{\sqrt{2}} * \gamma * H - CH \qquad (1)$$

In which: γ is the volume of soil, kg/cm^3; B is the width of excavation, cm; H is the depth of excavation, cm; C is the cohesion of soil, kg/cm^2. At that time, the strength of load P_v is determined by the formula 2:

$$P_V = \gamma * H - \frac{\sqrt{2} * C * H}{B} \qquad (2)$$

Limited bearing capacity q_d of ground is represented by cohesion C and is determined by formula 3

$q_d = 5.7C$ (3)

According to Terzaghi, when the strength of load is beyond the limited bearing capacity q_d of ground, the problem of emergence occurs in the bottom of excavation and the phenomenon is displayed by coefficient of safety factor K.

$$K = \frac{P_d}{P_V} = \frac{5.7C}{\gamma * H - \frac{\sqrt{2} * C * H}{B}} \qquad (4)$$

When K > 1.5, this problem is not likely to occur; when K < 1.5, it will occur.

Table 3 The table of audit on the emergence in bottom of excavation at area of Hue city.

Type of ground structure	Deep excavation H (m)	Cohesion (C, kg/cm^2)	Width (B,cm)	Depth (H,cm)	Density (γ, kg/cm^3)	Coefficient of Safety (K)	Criterion
IIAa	3	0.11	2100	300	0.00189	1.15	< 1.5
	6	0.05	2100	600	0.00205	0.24	< 1.5
	9	0.05	2100	900	0.00205	0.16	< 1.5
IIAb	3	0.11	2100	300	0.00189	1.15	< 1.5
	6	0.09	2100	600	0.00167	0.53	< 1.5
	9	0.09	2100	900	0.00167	0.54	< 1.5
IIB	6	0.13	2100	600	0.00202	0.66	< 1.5
	9	0.11	2100	900	0.00186	0.63	< 1.5
IIIAb	3	0.05	2100	300	0.00163	0.59	< 1.5
		0.06	2100	300	0.00183	0.64	< 1.5
	6	0.05	2100	600	0.00163	0.29	< 1.5
		0.17	2100	600	0.00203	0.84	< 1.5
	9	0.05	2100	900	0.00163	0.19	< 1.5
		0.17	2100	900	0.00203	0.56	< 1.5
IIIB	3	0.10	2100	300	0.00190	1.04	< 1.5
		0.15	2100	300	0.00207	1.47	< 1.5
	6	0.15	2100	600	0.00207	0.73	< 1.5
		0.17	2100	600	0.00203	0.84	< 1.5
	9	0.17	2100	900	0.00203	0.56	< 1.5

Based on Terzaghi's theory, we have conducted the audit on the problem of emergence in the bottom of excavation corresponding to the depth of 3 meters, 6 meters, 9 meters on all different types of ground structure of the survey area, except the type III. The technical parameters and audit results are shown clearly on Table 3. From Table 3, we can see the coefficient of safety K of excavation alters from 0.16 to 1.47 (< 1.5). These values demonstrate that this problem is very likely to occur and the deeper excavation is, the more easily the problem arises. Thus, we find it necessary to have methods to stabilize the bottom of excavation.

- Inrush of the bottom of excavation: This phenomenon occurs when digging of excavation reach near the confined aquifer but the thickness of waterproof formation (clay) at the bottom of excavation is not thick enough to resist the pressure. Thus, the small water jets erupt from the bottom of excavation and spread as slimy liquid within excavation (Figure 5).

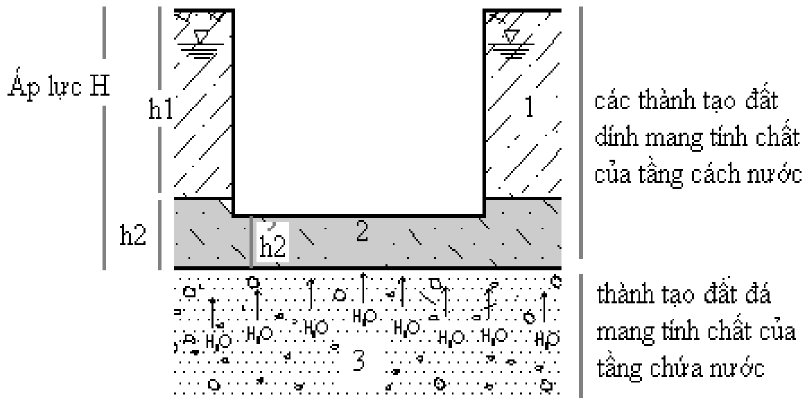


Figure 5 Imitative diagram of the problem of inrush at the bottom of excavation.

Evaluation of the ability of this problem depends on the stability factor K_y

$$K_y = \frac{P_{cz}}{P_{wy}} = \frac{\gamma_w . h}{\gamma_n . H} \tag{5}$$

In which: P_{cz} is the weight pressure of soil from the bottom of excavation to the roof of confined aquifer; P_{wy} is the pressure of confined aquifer; H is the pressure of aquifer (cm); h is the thickness of confined aquifer (cm); γ_w is the natural weight of soil; γ_n is the specific density of water, γ_n = 1 g/cm^3. This problem does not happen with $K_y > 1.05$.

Based on formula 5 and hydro-geological and engineering geological conditions of area, we have conducted the audit on the problem of inrush at the bottom of excavation in the different depths of ground structures which are likely to arise this problem (IAa, Iab, IIAb). The result of calculation shown in Table 4 indicates that the coefficient of stability of ground structures considered is from 0.06 to 0.71, and less than 1.05). Thus, when the deep excavation is built on ground structures of IAa, Iab, IIAb, the problem of inrush at the bottom of excavation is at risk.

Table 4 Audit table of the inrush at the bottom of excavation for the ground structures of IAa, Iab, IIAb in area of Hue city.

Type	Depth of excavation	Buoyant density (γ_{dn}, g/cm^3)	Thickness (h,cm)	Pressure (H, cm)	Coefficient of Safety K_y and criterion
IAa	3m (the bottom of excavation locates at 2b sub-class - plastic – soft sandy loam)	0.92 (2b sub-class)	40 (2b sub-class)	1050	0.71 < 1.05
		0.73 (3b,c sub-class)	240 (3b,c sub-class)		
		1.07 (4a sub-class)	500 (4a sub-class)		
	6m (the bottom of excavation locates at 4a sub-class - loam)	1.07	540	1050	0.55 < 1.05
	9m (the bottom of excavation locates at 4a sub-class - loam)	1.07 (4a sub-class)	220	1280	0.29 < 1.05
		0.83 (6a sub-class)	160		
IAb	3m (the bottom of excavation locates at 2a sub-class – blue grey loam, soft plastic)	0.94	120	420	0.27 < 1.05
IIAb	6m (the bottom of excavation locates at 3b sub-class – blue grey – black grey muddy loam, liquid)	0.66	60	660	0.06 < 1.05

- Land subsidence: This phenomenon is local or regional, connecting to the collapse of ground. The vertical movement may be a sudden collapse or a gradual decrease of the altitude of ground because of the lost gradually underground liquid, the escapement of interstitial from soil and rock or the oxidation of organic soil, etc. In civil construction, the land subsidence often occurs when implementing the excavation makes underground water to drain and lower the level of water. Then the soil organic is decayed and becomes oxidative, combined with physical compaction due to the movement of liquid, causing the subsidence of ground. When foundation of building is located in the soil with greater durability and under this formation is organic soil, the problem of land subsidence around a building is likely to leave big spaces between floor sheet and ground. This process occurs quickly or slowly depending on the level of drainage of water and quick or slow decrease level of underground water, then that causes subsidence, leaning, crack, even collapse of the building. Most noticeably, during implementing of excavation, the drainage of underground water affects not only building itself but also adjacent buildings (Figure 6).

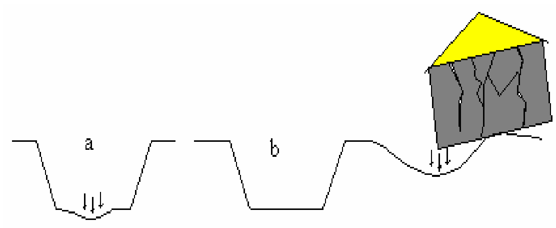


Figure 6 Subsidence of excavation (a),
Subsidence of excavation of adjacent buildings (b)

To assess this issue, Peck [3] built a experimental graph including 3 zones to estimate the settlement around excavation (Figure 7).

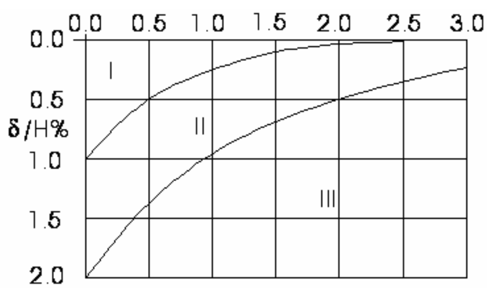


Figure 7 Experimental graph for estimate the settlement around excavation.

In which: H is the depth of excavation; S is the distance from desired point to wall of deep excavation and δ is the settlement need to be calculated.

In the diagram of Figure 7: Zone I is applied for sand and stiff plastic to stiff clay (undrained cohesion C_u > 30kpa), average levels of construction; Zone II is applied for soft plastic - liquid plastic clay; Area III is applied for soft plastic - liquid plastic clay in the depth of the bottom of excavation. Thus, we can estimate the settlement of ground in the following steps:

- Identify the soil for its ranks of the zone I, II or III.
- Calculate settlement at point i with the distance to the edge of excavation S_i. At that time we find out S_i /H
- From the point S_i/H of the horizontal axis and the curve of graph to find out the value δ/H (%)
- From the value δ /H and the depth of excavation H to find out the settlement δ

Results of the values of land subsidence on the types of ground structure such as IAa, IB, IIB, IAb and IIA are shown by Table 4 and 5.

Table 5 Values of land subsidence during the construction of basement on the ground structure IAa, IB, IIB

Distance from expected point to excavation wall S_i (m)	**S_i/H**	**δ_i/H**	**Subsidence value**
1 basement (3m)			
0	0.0	1.000	0.03000
3	1.0	0.250	0.00750
6	2.0	0.125	0.00375
7.5	2.5	0.000	0.00000
2 basements (6m)			
0	0.0	1.0000	0.0600
3	0.5	0.5000	0.0300
6	1.0	0.2500	0.0150
9	1.5	0.1250	0.0075
12	2.0	0.0625	0.0375
15	2.5	0.0000	0.0000
3 basements (9m)			
0.0	0.0	1.0000	0.0900
4.5	0.5	0.5000	0.0450
9.0	1.0	0.2500	0.0225
13.5	1.5	0.1250	0.0113
18.0	2.0	0.0625	0.0056
22.5	2.5	0.0000	0.0000

Table 6 Values of land subsidence during the construction of basement on the ground structure IAb and IIA

Distance from expected point to excavation wall S_i (m)	S_i/H	δ_i/H	Subsidence value
1 basement (3m)			
0	0.0	1.500	0.0450
3	1.0	0.563	0.0169
6	2.0	0.281	0.0084
9	3.0	0.125	0.0038
12	4.0	0.000	0.0000
2 basements (6m)			
0	0.0	1.500	0.0900
3	0.5	0.938	0.0563
6	1.0	0.563	0.0338
9	1.5	0.438	0.0263
12	2.0	0.281	0.0169
18	3.0	0.125	0.0075
24	4.0	0.000	0.0000
3 basements (9m)			
0.0	0.0	1.500	0.1350
4.5	0.5	0.938	0.0844
9.0	1.0	0.563	0.0506
18.0	2.0	0.281	0.0253
27.0	3.0	0.125	0.0113
36.0	4.0	0.000	0.0000

- Excavation walls slide: This problem occurs when soil - rock around the excavation is instable, tends to destruct and moves towards the bottom of excavation, that makes the shape of excavation changed. The factors which make excavation walls instable may be soil - rock composition, gravity, hydrodynamic pressure, seismic force, natural topography. Thus, the sliding surface is likely to appear in depths with different shapes depending on the excavation wall. To audit the ability of slide for ground structures in the area of Hue city, we use the sliding method of cylindrical arc having center O and radius R of V. Fellenius as follows:

$$\eta = \frac{\sum \text{resisting moment}}{\sum \text{causing moment}} \Leftrightarrow \eta = \frac{\Sigma W_i.\cos\alpha_i.tg\phi_u + C_u.L}{\Sigma W_i.Sin\alpha_i} \qquad (6)$$

With: W_i is the weight of considered soil for landslide $W_i = \gamma.S_i$ (Ton); S_i is the area of slide block; α_i is the declination of slide block; C_u is the cohesion of soil, rock (T/m^2); φ_u is the internal angle of friction (degree); L is the length of slide arc; η is the safety coefficient of slide (the ratio of total resisting moment to total causing moment), excavation walls reach stable state when $\eta > 1$. Based on this method and physical - mechanic properties of soil - rock, we have carried out the audit for the slide of excavation wall during implementing the high building using deep excavation for ground structures such as IAa, IAb, IIAb, IIB. The results are shown clearly by Table 6.

Table 7 The results of stability coefficient of excavations of ground structures IAa, IAb, IIAb, IIB

Type	Radius R (m)	Length of slide arc L_i (m)	Buoyancy force of water ΣU.l	$\Sigma W_i.Cos\alpha_i$	$\Sigma W_i.Sin\alpha_i$	Stability coefficient η
IAa (I61 borehole)	3.2	5.024	2.17	12.47	6.18	1.17
	5.2	8.164	11.44	31.53	15.62	0.63
	9.0	14.13	48.60	111.33	84.57	0.27
IAb (I73 borehole)	2.0	3.14	-	4.82	2.39	1.39
	2.9	4.55	1.32	10.13	5.02	0.99
	3.8	5.97	4.36	17.43	8.64	0.83
	7.2	11.3	28.35	59.37	29.41	0.39
	12.9	20.25	122.79	203.45	100.8	0.26
IIAb	3.3	5.18	2.5	12.84	6.36	0.36
	4.8	7.54	9.27	27.16	13.46	0.27

(I2 borehole)	5.5	8.64	13.7	35.87	17.77	0.29
	10.8	16.96	80.3	138.32	68.53	0.15
IIB	2.7	4.24	0.87	9.53	4.72	1.1
	8	12.6	37.77	84.92	42.08	0.51
(I4 borehole)	9.5	14.9	58.23	119.17	59.00	0.47
	11.5	18.1	93.21	174.63	86.52	0.42

From the Table 6, we know in the ground structures considered, the slide of excavation wall is all likely to occur. The deeper excavation is, the more easily the slide becomes. It means the safety coefficient η is contrary with the depth of excavation.

Besides, the considered area has sallow level of underground water (commonly less than 2 meters). Thus, when one builds the excavation, the underground water will be absorbed to cause excavation flooded and reduce the stability of ground, the contraction increased, then the building will appear a large settlement under the load itself and soil's stress makes the addition to the settlement for foundation. However, due to the limited framework of report, we have not mentioned yet.

CONCLUSION

From the above results, some conclusions and recommendations could be given as follows:

In the study area types of ground structures are mainly distributed by IAa, IAb and IB with fewer appearance in southwest and IIB at Southeast of the study area.

The engineering geological problems during construction of deep excavation occurs frequently in the ground structures types IAa, IAb. Specifically, they are the emergence, the inrush of the bottom of excavation, land subsidence, excavation wall slide and water flowing into excavation.

Depending on the spatial distribution and physical - mechanical properties of soil - rock, the hydrological conditions, etc., in the other ground structures, the engineering geological problems occurs less than the above ones when the deep excavation is executed.

Engineering geological survey for the civil – industrial construction with basement need to be deployed as for underground buildings to supply necessary data for forecasting the engineering geological problems as well as for proposing solutions, calculations to stabilize construction protecting excavation.

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