BASES AND FOUNDATIONS, UNDERGROUND STRUCTURES

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TECHNIQUE OF GEOTECHNICAL MAPPING SUBJECT TO RECOMMENDATIONS ON SELECTION OF OPTIMAL FOUNDATION TYPES FOR BUILDING WITH UNDERGROUND AREA (BY THE EXAMPLE OF HO CHI MINH CITY)

The technique of geotechnical mapping for the purpose of optimal arrangement of different types of foundations subject to building underground area development is proposed. The results of the application of the technique for the ground conditions of Ho Chi Minh City (Vietnam) are presented.

Keywords: geotechnical maps, underground area, box-type foundation, optimal foundation.

Introduction

In recent years special geotechnical maps have assumed more and more significance in design practice. This maps allow one to make the most efficient use of real ground conditions on building development of large areas of land. The principles of mapping

are based on the works of R. A. Mangushev, G. V. Shtokalenok, S. N. Sotnikova, N. N. Morareskul, L. G. Zavarzin, et al. [1, 2]. The principles and criteria for mapping may significantly differ depending on the tasks they fulfill.

We propose the technique of geotechnical mapping for arrangement of different types of foundations subject to building underground area development with the view of increasing the number of storeys of Ho Chi Minh City built-up area.

Optimal foundation

The optimal foundation is one that fulfils basic technical and economic requirements. This foundation must provide conditions of strength limiting state of construction and foundation (1) as well as conditions of foundation deformation limiting state (2). It also must comply with the local level of construction technology (3) and provide minimum construction costs (4). Depending on ground conditions and foundation type requirements (1) and (2) play the main role in determing the foundation parameters.

We developed the technique (see Fig. 1) for the foundation of the buildings being designed with regard to underground areas. The technique consists of following basic stages.

The first stage (I) involves area zoning with consideration for conditionally homogeneous engineering geological zones, ground condition typification for each zone being performed. The thickness of weak grounds layer or depth of occurrence of reliable grounds layer is recommended as the basic criterion for zoning.

The second stage (II) involves determination of tentative parameters for foundation arrangement (for pile and box-type foundation subject to underground area using). Optimal parameters for pile foundation are determined with the use of the technique proposed in [1, 2], based on value ratio and pile bearing capacity.

The technique proposed in [3] is recommended when it is necessary to determine tentative parameters for box-type foundation subject to underground area using. Foundation parameters are determined on the basis of deformation limiting state using computer programs.

The results of calculation are presented in the form of dependence of number of storeys on variant of underground parts arrangement. The result of this stage is the geotechnical map with recommendations on rational development of underground areas.

The third stage (III) involves determination of foundation optimal types based on variant technical and economic comparisons. This has the effect of geotechnical mapping with recommendations on optimal foundation type for building with different number of storeys.

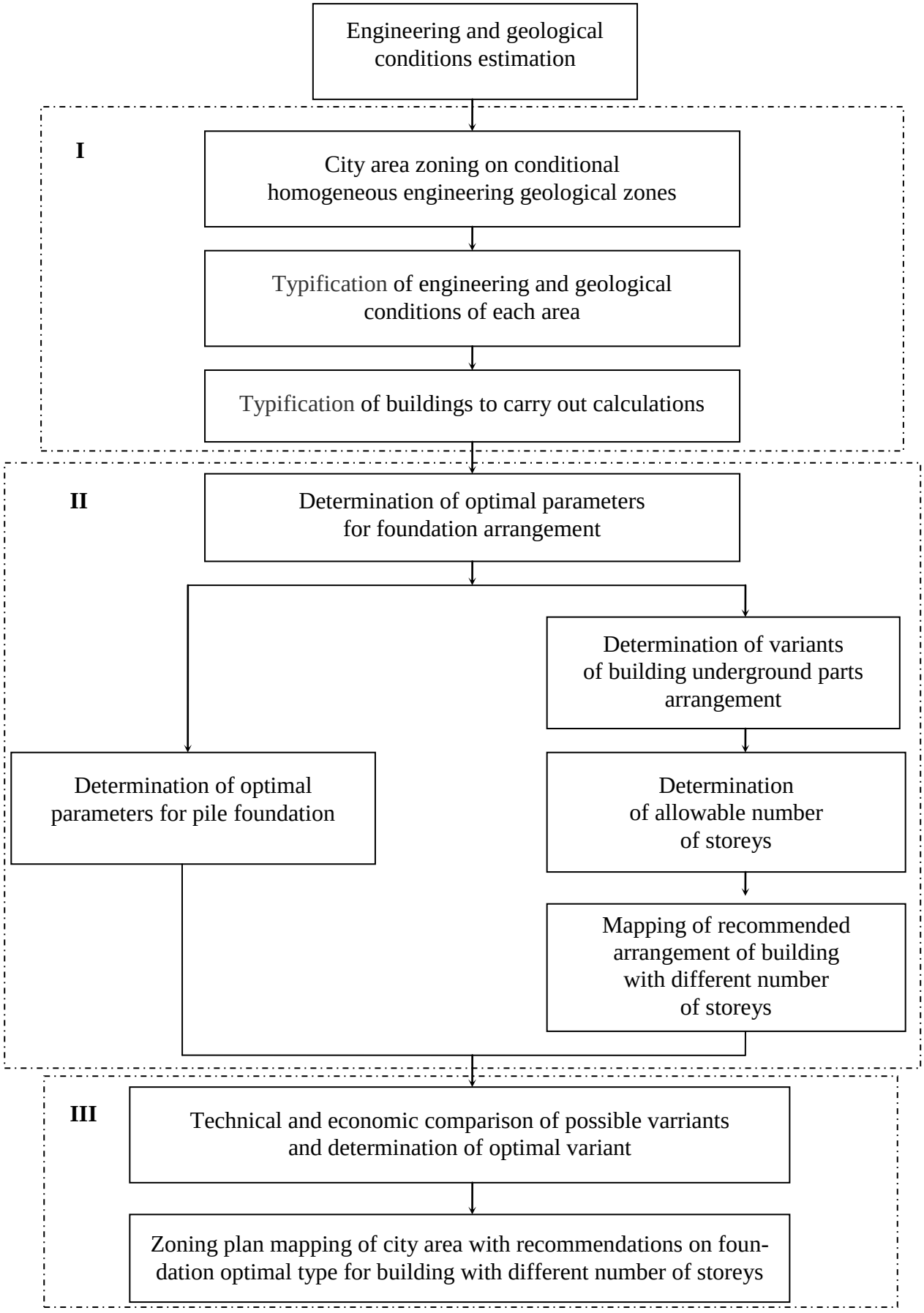


Fig. 1. Block-diagram of the proposed technique

1 m^2 of the building total area can be taken as a measurement unit for comparison. Consequently, cost index C_i is proposed to be taken as technical and economic comparison criterion.

The cost index C_i is the ratio between total cost of foundation construction $C_ф$ (that is the sum of construction cost and economic efficiency cost) and total construction area of the building A, underground area included:

$$C_i = \frac{C_ф}{A}. \quad (1)$$

When using this approach, the efficiency of underbuilding area is estimated through increase of underground area and economic effect because of its use.

Minimum values of cost index C_i make it possible to draw tentative conclusion concerning optimum variant of foundation arrangement. The additional efficiency criteria, such as material and money saving, are used for equivalent foundations.

Using proposed method we determined optimal foundation types for Ho Chi Minh City. City area zoning was carried out on the basis of available engineering geological zoning maps, with additional criterion being used, such as the thickness of weak grounds, depth of occurrence and degree of acidic aggression of groundwaters.

As a result of zoning, construction area of the city (zones *A* not included) was divided into 12 conditionally homogeneous engineering-geological zones (Fig. 2). The typification of ground conditions for each zone was also carried out [3].

As for Ho Chi Minh City, pile, pile-and-slab and box-type foundations are recommended when constructing building with number of storeys exceeding 8 with the use of underground areas.

The tentative parameters for foundation variants under comparison for each conditionally homogeneous zone were presented in [4].

The technical and economical comparison assumes that the estimated cost of foundation works in city area is determined based on cost estimation standard [5] and analysis of underground structure practical cost.

Then the cost of certain foundation works is alculated by the formula

$$C = 1.1 \times (C_з + C_в + C_м + H_p), \quad (2)$$

where 1.1 is the coefficient allowing for the tax; $C_з$ is the material cost determined by aggregative estimating standards; $C_в$ is the direct estimated labor expenditures determined by cost estimation regulations; $C_м$ is the estimated machine costs; $H_p = 0.06 \times (C_з + C_в + C_м)$ is the overhead expenses.

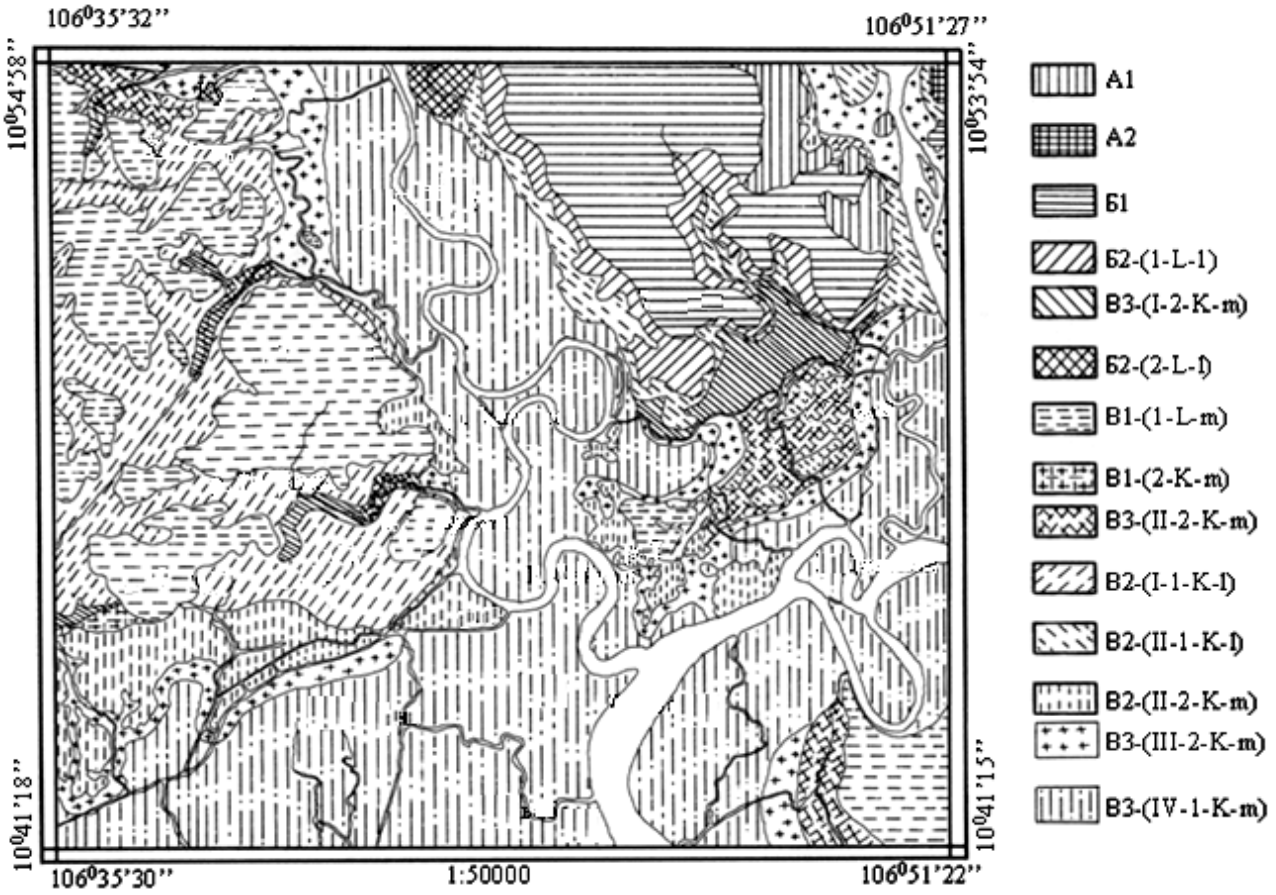


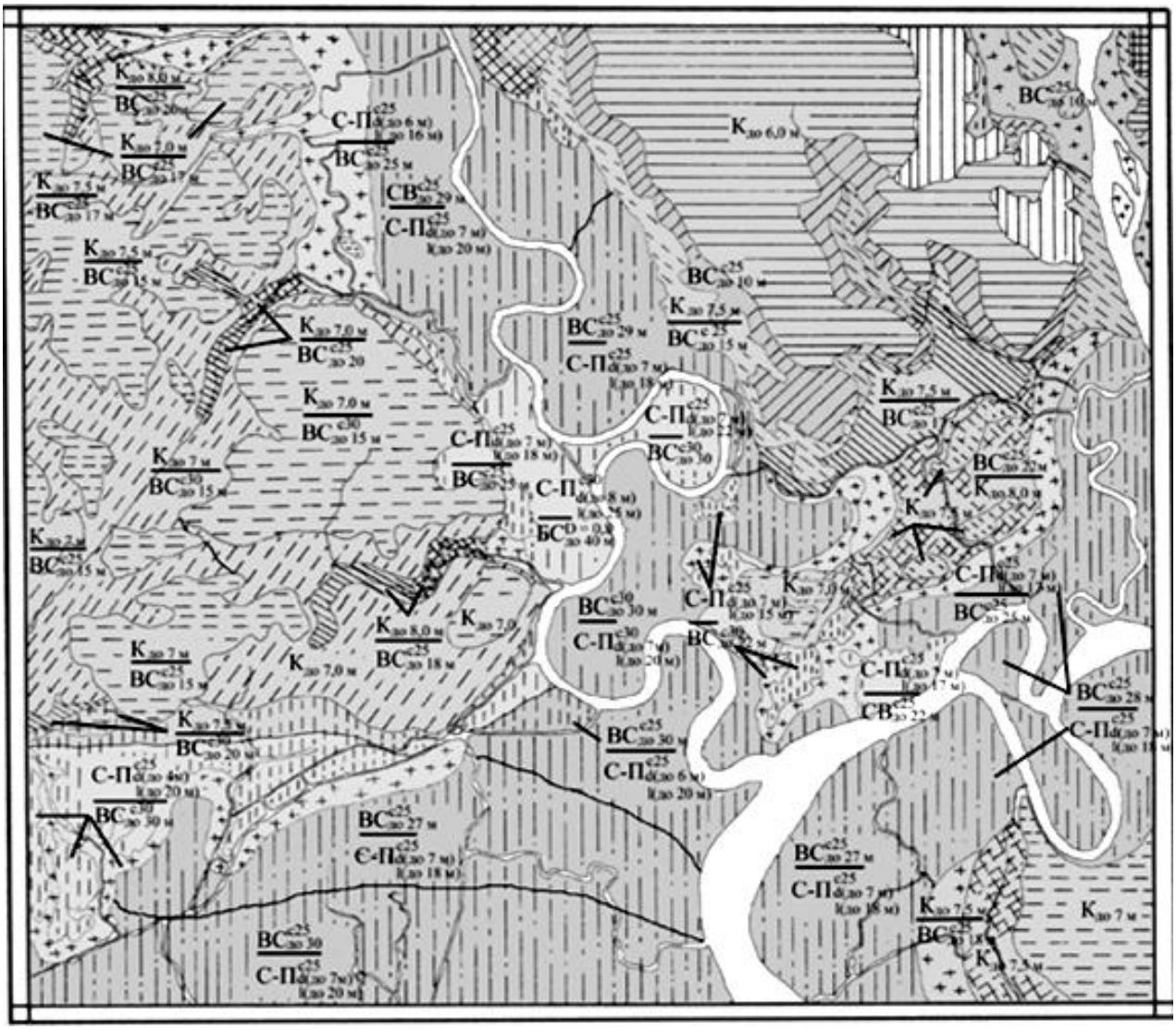
Fig. 2. Map of engineering geological zoning of city area

Furthermore, cost of construction is influenced by local technology level. In accordance with city construction technology, the following assumptions are used to calculate the underground area construction costs:

- for building with one underground floor (depth less than 3 m) underground area construction costs are estimated subject to the fact that foundation pit wall stability should be provided with the use of slopes or Larsen Rabbet;
- for building with two underground floors (depth less than 8 m), underground area construction costs are estimated subject to the fact that foundation pit wall stability should be provided with the use of Larsen Rabbet;
- for building with more than two underground floors foundation construction costs is estimated having regard to subsurface portions arrangement being made using the technique "walls in soil".

Economic efficiency of use of building underground areas can be evaluated by market price. As for city area, use of underground areas for parking, 25 m^2 per car, is the most popular. We proposed to use market price of parking space lease ($ц$) to make technical and economic comprasion between foundation arrangement variants.

The technical and economic comprasion has been made for types of building which are usedvery widely in Ho Chi Minh City nowadays. The maps with recommendations on optimal foundation type for building with different number of storeys were compiled. For instance, see the maps for building with number of storey less than 20 on Fig. 3.



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$К_г$	box-type foundation
$ВС^{с}_{д}$	pile foundation with impressed piles
$БС^{с}_{д}$	pile foundation with drilled piles
$С-П^{с}_{д}$	pile-and-slab foundation

г	depth of slab laying
с	type of piles
д	length of piles
до	means “up to”
м	means “meter”

Виды свай

Title	Pile type	Size, m
C25	Precast	0.25x0.25
C30	Precast	0.3x0.3
C35	Precast	0.35x0.35
Б80	Drilled	D=0.8
Б100	Drilled	D=1.0
Б120	Drilled	D=1.2
Barret	Barret	-

Fig. 3. Map of zoning of Ho Chi Minh City with recommendations on optimal foundation type for building with number of storey from 15 to 20

The Table shows the results of use of above-named geotechnical maps for three real buildings.

As one can see, the variants proposed provide conditions for deformation limiting state and have less construction costs in all these buildings.

Table

Results of technical and economic comprasion for certain real objects

Variant	Zone	Settlement, cm	Number of storeys	Total area, m^2	Foundation construc-tion costs, USD	Efficiency, USD	Cost ratio
Dwelling house Chiong Diong							
Actual variant: pile foundation with 298 piles of diameter 1 m, length 44 m	B3-(III-K-m)	2.3	22	H:52470 П:4390 56860	3103482	505728	45.6
Proposed variant: pile and slab foundation, depth of foundation 7 m, with broadening of subsur-face areas		9.7	22	C: H:52470 П:8780 61250	1266836	842880	6.9
Building of Shakombank firm							
Actual variant: pile foundation with 116 piles of diameter 1 m, length 30 m	B2-(I-K-l)	4.3	17	H:19125 П:2652 21777	1398730	309400	50.0
Proposed variant: box-type foun-dation, depth of foundation 7 m		8.2	17	H:19125 П:2652 21777	503560	221000	12.9
Dwelling house Thang Miloy							
Actual variant: pile foundation with 246 piles of size 0.35×0.35 m, length 23 m	B2-(II-K-m)	3.2	15	H:13219 П:881 14100	339453	100800	16.9

End of Table

Variant	Zone	Settlement, cm	Number of storeys	Total area, m^2	Foundation construction costs, USD	Efficiency, USD	Cost ratio
Dwelling house Thang Miloy							
Proposed variant: pile and slab foundation, depth of foundation 7 m, with 225 piles, 0.25×0.25×17 m	B2-(II-K-m)	8.5	15	H:13219 П:1762 14981	327873	168000	10.6

The major points covered by this paper must be summarized as follows.

1. With the use oa proposed technique geotechnical maps can be compuled and used not only for city in the whole, but also for certain areas on the stage of general plan of city development.

2. Designing of skyscrapers in Ho Chi Minh city often involves unreasonable foundation arrangement, which results in inflated construction costs.

3. Use of geotechnical maps with developed recommendations on optimal type of foundation on initial designing stage allows foundation construction costs to be significantly reduced.

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