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A FOUNDATION SUITABILITY MAP OF NANJING CITY, JIANGSU PROVINCE, P. R. OF CHINA *

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Abstract To meet the growing requirements for suitable and safe constructional lands, methods of land-use evaluation are being rapidly developed in engineering geology. The paper deals with setting up a foundation suitability map for Nanjing city. The bedrock geology, topography, the depth to the bedrock and the Quaternary geotechnical soil maps are utilized to achieve this goal. For simplicity and from practical point of veiw, the pre-existing maps are modified in simple versions. Each map is separated into areas of different ranges. The zoning map of the engineering geological conditions is prepared by simple superimposing transparent overlays of the four basic data maps. Each zone is rated and five classes of ground conditions are fabricated.

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1 Introduction

Geology has played an important role in urban land-use and development. History reveals that human settlements and the creation of the present day cities are controlled by geology, ease of transportation, fertile soil and many other factors. Nanjing belongs to such kind of cities which was developed from historical sites of the early settlers. The city being along major waterway (Yangtse River) is of easy access for its inefficient transportation at that time. Nevertheless, even the early settlers had already applied their knowledge in geology because the present old town centers are relatively free from major geological hazards.

The topography of Nanjing is mostly flat and lowlying at the central and eastern parts of the city with the exception of a few sporadic hills. The initial settlements were in these zones. However, as the population increased, the settlements expand to occupy the backlands

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which are normally of higher ground (the river terraces) and undulating hills. Such situation had been created many of geological constraints/hazards that might be exaggerated in the near future if they are not seriously considered by the authorities.

From a communication point of veiw, the geologists cannot provide the planners with a typical geology map and expect to fully communicate the impact of geological conditions on land-use. The geologic data must be converted to a form which can be used by the authorities often unskilled in earth sciences and their interpretation. To achieve this goal the concept of the engineering geological zoning map has been introduced. Actually such maps hide under many different names, e. g. environmental geology maps, land-capability maps, geopotential maps, and so on.

Our approach is to attempt to classify the city area into different zones of similar characteristics through the utilization of different geological components. The most desirable zones are where favorable components coincide and the least desirable zones where unfavorable factors coincide. The zones can then be ranked by weighing favorable and unfavorable factors for special purpose zoning maps.

2 Geologic Setting

2.1 Quaternary Deposits

The study area is underlain almost entirely by Quaternary sediments. Chronologically, two major sedimentary groups are recognized: Holocene and Pleistocene deposits. The former group is subdivided into three sedimentary facies:

1. The floodplain deposits of Yangtse river: These deposits form relatively wide belt along the banks of Yangtse river. Beside silt, fine sand and rare gravel with minor to abundant plant remains are encountered. The depth to the bedrock increase gradually from a few meters near the terrace area to more than 60m near the river course.
2. The floodplain deposits of Qinhuai river: They mainly occupy the middle flat lowlying area of the city in a form of N-S sedimentary belt of clayey silt. This belt is confined on both sides by the terrace area. These deposits overlie different lithologies of pre-Quaternary basement rocks, and in places rest directly on the foots of the Pleistocene deposits.
3. The infill deposits of Qinhuai paleo-channel: The existence of these deposits along the ancient channel of Qinuai river was proved in the last three decades[1]. The channel is generally trending N-S (Fig. 1), and deeply anchoring into the pre-Quaternary bedrock, where more than 40m of sediments were reported. The infill deposits are mainly made up of friable, unbeded combination of sandy and silty clay.
4. The burried gully deposits: They occur widely to the west of the city, at the ancient lower slopes or valley margins. Lithologically, they reflect the characteristics of their parent materials which are mainly of Pleistocene chayey sediments.

With regard to the Pleistocene group, the locally named Xiashu formation had been identified to be a unique litho-facies among this group. Geomorphologically, the Xiashu formation

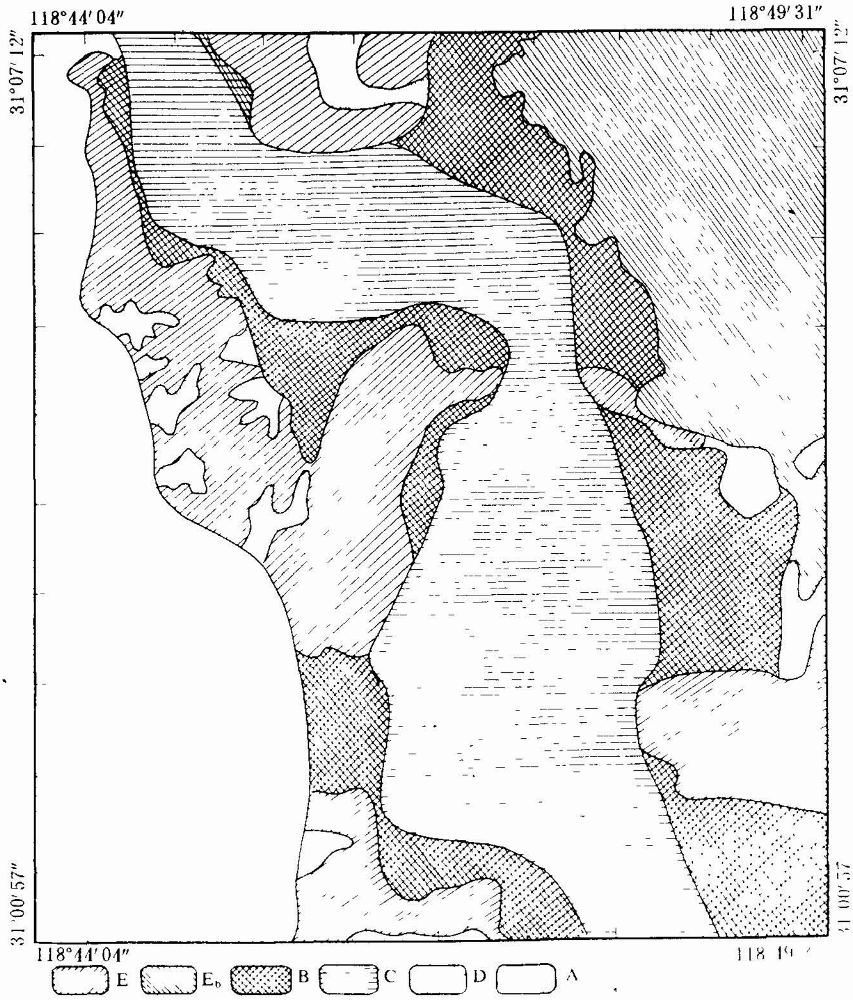

Fig. 1 The Quaternary engineering soil types of Nanjing city.

The classification and rating of these soil types is based on their physical parameters as shown in Table 2—a. For the legend explanation refers to Table 1.

图 1:南京市区第四纪工程土类型图。

这些土类型是据表 2—a 所示的物理参数划分的。图例解释参照表 1。

can be subdivided into two main subfacies:

1. First order terrace: It mostly occupies the western part of the city area adjacent to the eastern limit of Yangtse′s flood plain. It consists of homogeneous cohesive clay and rare silty clay with thickness range from 1m to more than 20m. In small scale, these deposits were also reported in the eastern sector of Nanjing to gether with their equivalents of second order terrace.
2. Second order terrace: Here, the Xiashu formation is distinguished from that in the first order terrace by its clastic behaviour. In general, the content and size of the clasts increased as the formation thickness decrease. In other words, the shallower the depth to bedrock,

the higher clasticity and bigger size of rock fragments. However, these bouldery cohesive materials almost have less than 20m depth to the basement rock.

2.2 Bedrock Geology

The bedrocks are mostly exposed at the borders of the city as low inselbergs (e.g Fuguishan) and relatively short-low rise mountains (e.g. Beijigeshan). Hereabout, the Xiashu formation have been stripped or occur as thin blanket on the tops and the slopes of the hills. Elsewhere, depth to the bedrock range from 1m to more than 60m. Nanjing bedrocks range in age from middle Cambrian to lower Cretaceous. They made up of argillaceous, arenaceous and calcareous sedimentary rocks as well as intermediate plutonic rocks. Geotechnically, they range from fissured, permeable and weak to hard impermeable massive rocks[2]. These geotechnical names will be used in the proceeding sections instead of the traditional petrological nomenclatures.

3 Geological-Geotechnical Constraints

In urban development of Nanjing, the common geological constraints/hazards encountered are slope failure, foundation problems and flooding. A brief account on these problems are as follows:

3.1 Foundation Problems

Foundation problems are the most important constraints/hazards to urban development in Nanjing. These problems are mainly due to the extensiveness and thickness of soft sediments on which the center of the city is built.

The silt and fine sands of the Yangtse river levee deposits are soft and highly compressible with high water content. The high water content resulted in extreme engineering behaviours such as excessive compaction or settlement when drained giving rise to different foundation problems. Moreover, The surface ground conditions is always water logged and loose.

With regard to the Qinhuai paleo-channel deposits, the situation does not seem better than the former facies, but, it seems to be more protected from flooding by Yangtse river. Liquification is one of the most problems that can be easily triggered by any kind of shocks (e.g, earthquake and irrational digging for deep foundation). However, for urban development (particularly for heavy structures) in these geological settings, excavation and earth filling or deep piling have to be undertaken. This results in high costs particularly in the flood plain of Yangtse river where the thickest accumulation of soft soil occurs. The burried gully deposits can also be included under the term of soft soil.

While the geotechnical properties of these soils are extremely poor for heavy structures, bedrocks can provide a high quality base. Therefore, the relative depth to the bed rocks and the extents of these various alluvial deposits are important.

The flood plain deposits of Qinhuai river occupy an intermediate order between the above geological settings and the cohesive clayey material of the Xiashu formation.

3.2 Slope Stability

Landslides are the main hazards in the hilly area of Nanjing city. Since the Xiashu formation is widely distributed, landslides often happened, especially when it is just over the steep rock slopes. The landslides happened in Xiashu clay were usually caused by the irrational digging and bad drainage; for example a heavy rain fall in 1991 caused ten landslides in Nanjing[3].

3.3 Solid Wastes

Most of the waste disposal sites in Nanjing city (nine sites) lie in the areas where hydrogeologic conditions are unfavorable, for example, faults were developed in some sites, and some lie on collapsed limestone[3]. Moreover, some sites are near the urban district. Therefore, it is urgent to select some new sites so as to satisfy the rapid increase in population growth (now there are more than 5 million people living on an area of about 122km^2).

However, the best sites are those in which natural conditions insure reasonable safety in disposal of solid wastes; conditions may be safe because of climatic, hydrologic or geologic conditions or combinations of these[4]. In short, the following guidelines should be followed in site selection of waste disposal[5]:

- Limestone or highly fractured rock quarries and most sand gravel pits make poor site because these sites are good aquifers.
- Swampy and muddy areas, unless properly drained, make poor sites.
- Clay pit, if kept dry, may provide satisfactory sites.
- Flat upland areas are favorable sites providing an adequate layer of impermeable material.
- Flood plains likely to be inundated by surface water should not be accepted.
- In rough topography, the best sites are near the head of gullies where surface water is at minimum.

3.4 Flooding

As mentioned earlier, the western parts of the city are located in lowlying flood plains which are only a few meters above the water level of the Yangtse river. Hereby, flooding can be a serious hazard. The central lowlying part of the city seems to be more safe, but the rapid urbanization in this area have led to increase of impervious cover (e. g. roofs, pavement and cement). Consequently, once the city invaded by heavy rainstorms, a tremendous increase of runoff will take place . Hereon, the city center will be subjected to a series of intermittent flash-floods. For this reason, the improvement of the storm sewer system is very important because they allow urban runoff from impervious surfaces quickly reaching to stream channels.

4 Preperation of the Engineering Geological Zoning Map

4.1 The Kinds of Map Data Used

The following engineering geological components have been utilized in the production of such map. From practical point of veiw, some of already existing components were modified by the authors. All the maps had been conducted on a scale of 1 : 10,000.

1. The map of Quaternary unconsolidated materials: The summary description of these sediments is mentioned earlier in this text which include six facies. Herein, each sedimentary facies is treated as individual engineering group (Table 1, Fig. 1). The data of about 500 boreholes have been used to assess their geotechnical behaviours. The summary of the average geotechnical properties of each group is shown in Table 2—a.

Table 1 Classification of bedrock, soil types (with their depth to the bedrock) and slope gradient.

表 1 基岩,土(及其距基岩深度)类型以及斜坡坡度

QUATERNARY SOIL	PRE-QUATERNARY BEDROCKS
E cohesive non-bouldery soil of first order terrace (homogeneous clay)	i solid (hard) impermeable rock
E_b cohesive bouldery soil of second order terrace (clay with cataclasts)	j moderatly hard permeable rock
B moderatly cohesive soil of Qinhuai river flood plain (clayey silt)	k moderatly hard impermeable rock
C combination of moderatly cohesive and non cohesive soil of Qinhuai river's paleo-channel (clayey silt and sands)	l weak and highly fissured rock
D loess soil of the ancient burried gullies	
A non cohesive soil of Yangtse's flood plain (silt with organic material).	
DEPTH TO BEDROCK	**SLOPE GRADIENT**
1 <10m	c <5°
2 10—20M	d 5°—10°
3 20—30m	e 10°—15°
4 >30	f >15°

Table 2—a Classification and rating of engineering soils according to their physical parameters.

表 2—a 工程土分类(据其物理参数)

Engineering soil type*	E	E_b**	B	C	D	A
Wl	0.35		1.73	1.19	0.85	1.16
e	0.68		0.86	0.99	1.01	1.00
γ_d	16.1		13.8	13.5	13.7	13.3
C	53.8		16	24	22	14
a_v	209		402	243	438	437
E_s	9.35		5.3	7.8	4.7	4.2
Total rating score	5	4	2.81	2.3	1.5	

* See Table 1

** The blank rectangles of E_b having the same values of E. The total rating score of E is reduced by one to indicate the stony nature of E_b.

2. Slope gradient map: On the basis of the topographic map[6] the zonal boundaries of terrain slope map have been prepared (Fig. 2). However, such boundaries are not exact, because of the difficulty to line up points of equal slope gradient, based on topographic map contours

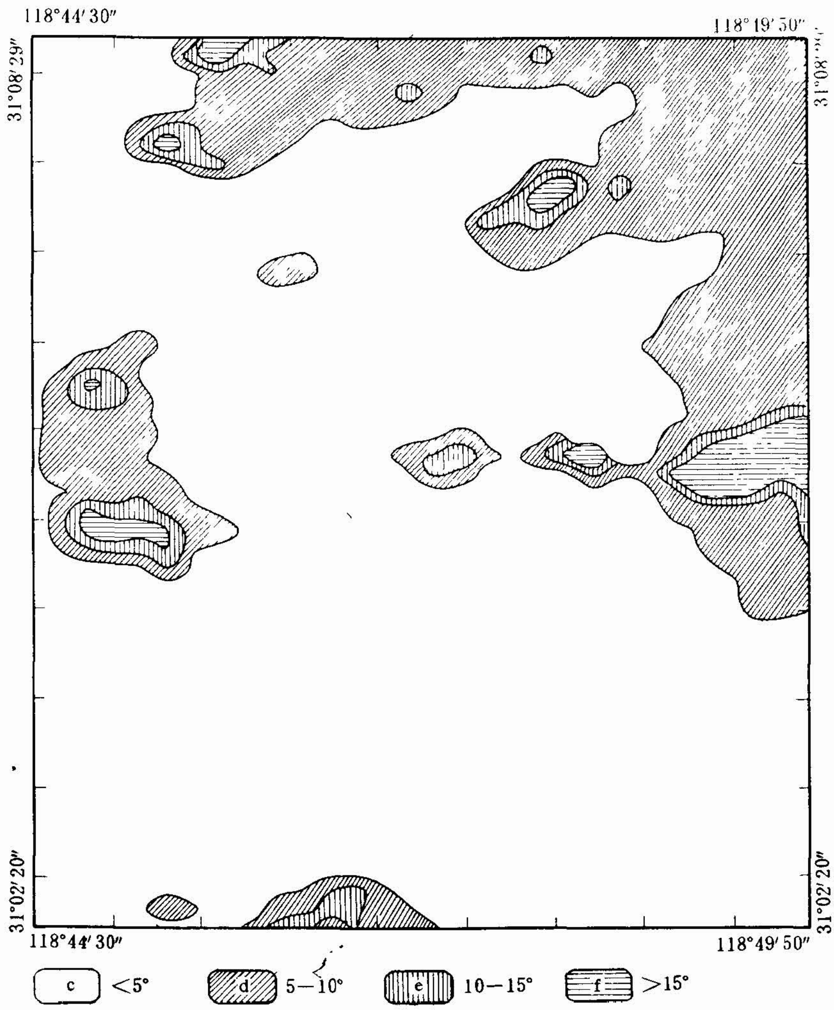

Fig. 2 The slope gradient map of nanjing city.

The classification and rating of land surface slopes is based on the slope type and hazard level (see Table 2—b).

图 2 南京市区斜坡坡度图。

地表斜坡的分级是据斜坡的类型和危害等级划分的(见表 2—b)。

only. The land surface slopes are divided into four grades. Table 1, Table 2—b shows the classification of these slopes according to their hazard potential.

Table 2—b Classification and rating of land surface slopes according to their hazard potential.

表 2—b 地表斜坡的分类(据其危害潜在性)

Slope range	<5°	5°—10°	10°—15°	>15°
Slope type	Flat	gentle	Moderate	Steep
Hazard level	No danger	Little danger	Some danger	Moderate danger
Rating score	4	3	2	1

3. Bedrock quality map: The original map was compiled by Jiangsu Architecture Design Institute (JADI)[7]. Due to the wide variations in its lithological characteristics, the JADI bedrock geology map has been transformed into a form, by which the different geological rock units are classified into four major engineering rock types (Table 1, Table 2—c; Fig. 3). The criteria used for such classification include texture, structure and degree of weathering. For example, the massive coarse—grained dioritic rocks are classified as hard impermeable rock unit; the highly fractured and strongly weathered volcanic suite is geotechnically ranked as weak permeable rock unit. In general, the present engineering rock types are ordered between these two extremes.

Table 2—c Rating of engineering bedrocks according to their geotechnical constraints.

表 2—c 工程基岩分级(据其岩土围限)

Engineering rock type*	i	k	j	l
Geotechnical constraints	No constraints	Little constraints	Some constraints	Moderate constraints
Rating score	4	3	2	1

* See Table 1.

4. Depth to bedrock map: The map have been compiled by Luo Guoyu et al.[2] in which the depth to the bedrocks is represented by contour lines. As it is impractical to use the same contour intervals through, due to the large changes in the gradient of the top of the bedrock, the original map has been modified in the present work to include only four major zones (Table 1, Table 2—d; Fig. 4).

Table 2—d Rating of depth to bedrock, based on the geotechnical characteristics of the Quaternary overburdens.

表 2—d 基岩埋深分级(据其第四纪覆盖物岩土特性)

	<10m	10—20m	20—30m	>30m
h	1.25	2.50	3.75	5
b	1	2	3	4
m	2.81	2.10	1.40	0.70
g	2.30	1.73	1.15	0.58
c	2.80	2.10	1.40	0.70
p	1.50	1.23	0.75	0.38

At the scale of the maps mentioned here, hydrogeological map would be of little value because of the general paucity of data on groundwater conditions. Similarly, a separate documentation map would serve little practical purpose.

4.2 Methodology

The current work was elaborated by using the methodology of Zugnette and Gandalfi[8], principle of Fookes[9], Matula[10] and Dearman et al.[11,12], as well as following the recommendations of the UNESCO-IAEG Guide to preparation of Engineering-Geological Maps[13].

The zoning map has been prepared by simple superimposing transparent overlays of the above mentioned four basic data maps. Hereof, the city area has been delineated into 128 indi-

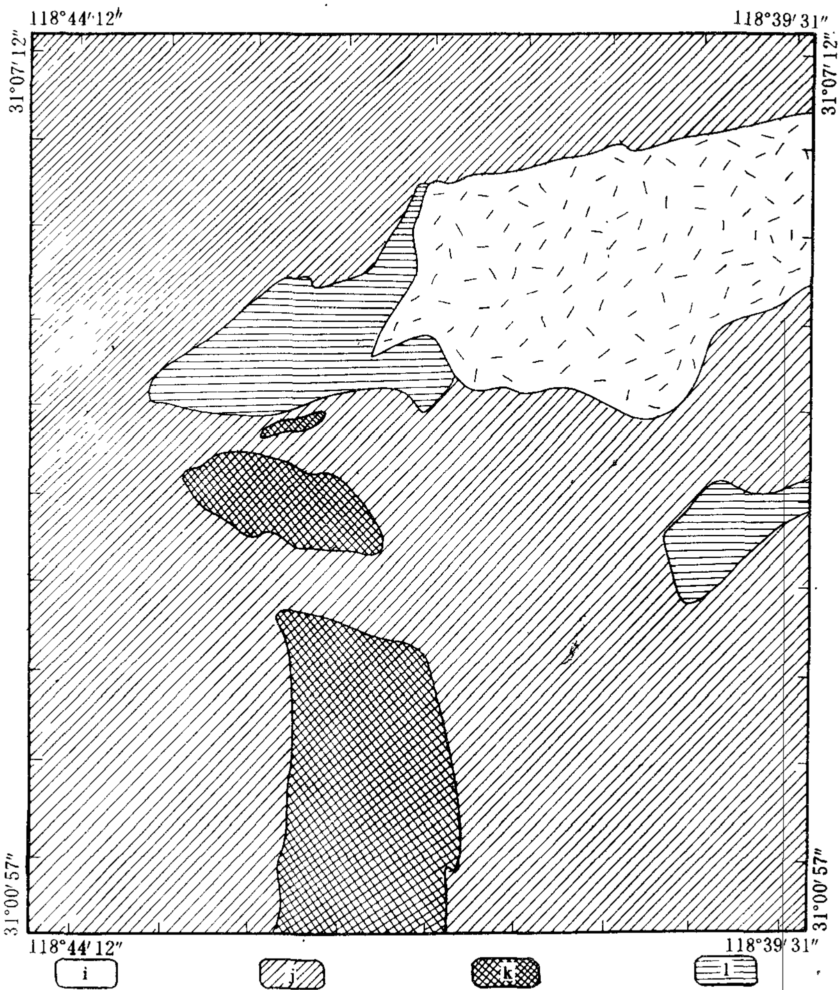

Fig. 3 The bedrock Quality map of Nanjing city.

The legends' illustration is shown in Table 1. The rating of the individual engineering bedrock units is explanined in Table 2—c.

图 3 南京市区基岩质量图。

图例说明见表 1,工程地质基岩单元分级详见于表 2—c。

vidual territorial units (Fig. 5). Zoning units in substance are three dimentional spatial models delimited on the basis of a certain uniformity in engineering geological conditions. Each territorial unit has been unequivocally assigned and coded (Table 3). In other words, each unit is indicated by a symbol which is formed by grouping the corresponding signs for engineering soils, engineering rocks, depth to the bedrock and slope gradient. For example, the symbol (E4ck) expresses a very well qualified ground model in which cohesive soil (>30m thickness) with slope gradient of less than 5 rest on a moderately hard impermeable bedrock.

At this step, the resultant map refers to so called multi-purpose map of engineering geological conditions. For special purpose zoning map, it is necessary to introduce the rating con-

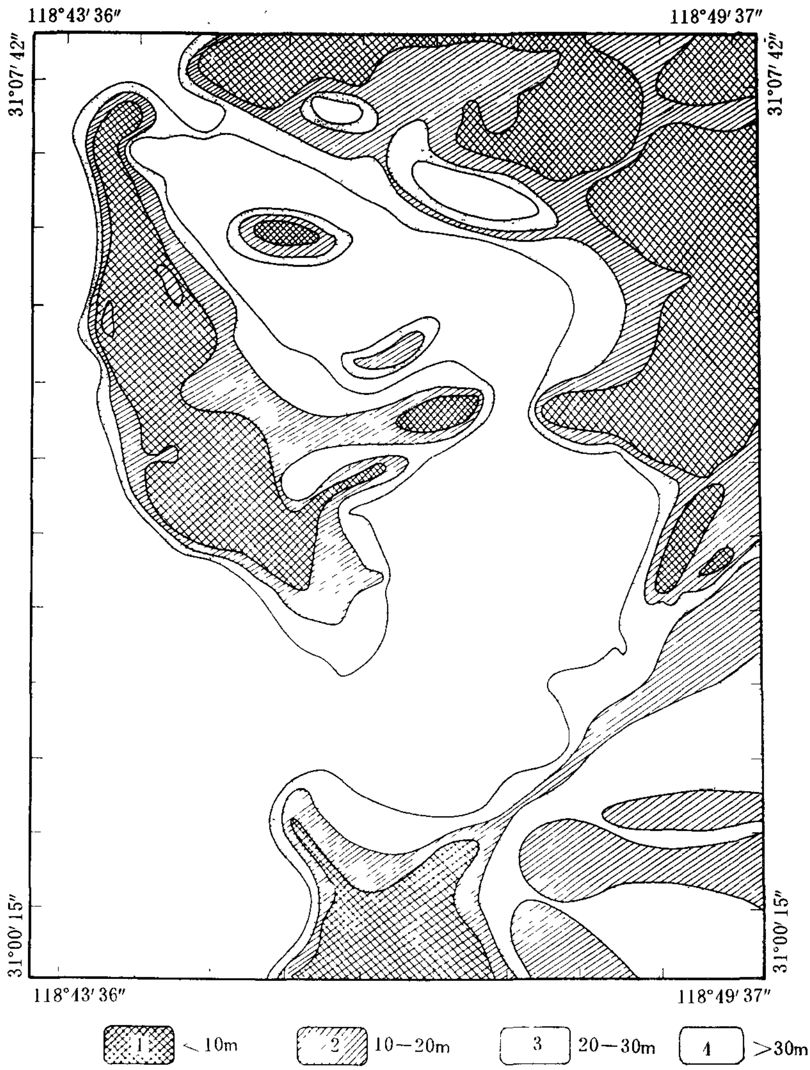

Fig. 4 The depth to the bedrock map of Nanjing city.

For legend description, refers to Table 1. The rating of the different zones in this map is based on the geotechnical characteristics of the overburden as shown in Table 2—d.

图 4 南京市区基岩埋深图。

图例说明见表 1。图中不同分区的分级是据表 2—d 所示的基覆盖物岩土特性划分的。

cept into the evaluation of the whole systems represented by the entity of those fundamental engineering geological components. The benifit of the rating concept is to reduce the large resultsnt number of ground conditions into few distinct combinations.. Here, the reproduction of the land development and construction map is considered as an example. This map is produced by following the hereunder rating technique. The result of rating is shown in Table 3.

With regard to the earlier mentioned six facies, their geotechnical properties are rated by utilizing the following physical parameters; liquid limits, void ratios, dry densities, cohesions, compressibility coefficients and modulus of elasticity. Hereunder, six steps have been followed for performancing this goal.

Table 3 The rating scores of the geotechnical zones shown in Fig. 5 according to the results present in Table 2

表 3 工程地质分区的各级参数(据表 2 的结果所得,分区示于图 5)

Zone symbol	Score	Zone symbol	Score	Zone symbol	Score
1-b4CI	13.6	44-E_b2ck	13.00	87-E_b1dk	11.00
2-B4di	12.6	45-E_b2dk	12.00	88-E_b1ek	10.00
3-B4ei	11.6	46-E_b2ek	11.00	89-E_b1fk	9.00
4-B4fi	10.6	47-E_b2fk	10.00	90-B1ck	10.50
5-c4CI	10.88	48-B2ck	11.21	91-B1dk	9.50
6-C4di	9.88	49-B2dk	10.21	92-C1ck	11.60
7-C4ei	8.88	50-C2ck	11.03	93-C1dk	10.60
8-C4fi	7.88	51-C2dk	10.03	94-E1cl	11.25
9-E4cj	16.0	52-E2cl	12.50	95-E1dl	10.25
10-D4cj	9.5	53-E2dl	11.50	96-D1cl	10.60
11-B4cj	11.6	54-D2cl	9.90	97-D1dl	9.60
12-C4cj	8.88	55-D2dl	8.90	98-B1dl	7.50
13-A4ck	8.88	56-E_b2cl	11.00	99-E3ci	16.75
14-E4ck	17.0	57-E_b2dl	10.00	100-E_b3ci	15.00
15-E4dk	16.0	58-E_b2el	9.00	101-E_b3di	14.00
16-D4ck	10.50	59-E_b2fl	8.00	102-B3ci	12.90
17-B4ck	12.60	60-B2cl	9.20	103-B3di	11.90
18-B4dk	11.6	61-B2dl	8.20	104-C3ci	11.45
19-C4ck	9.88	62-B2el	7.20	105-E3cj	14.75
20-E4cl	15.00	63-E_b1ci	13.00	106-D3cj	10.20
21-B4cl	10.60	64-E_b1di	12.00	107-B3cj	10.90
22-B4dl	9.60	65-E_b1ei	11.00	108-C3cj	9.45
23-C4cl	7.88	66-E_b1fi	10.00	109-A3ck	9.25
24-E2ci	15.50	67-B1ei	9.50	110-E3ck	15.75
25-E2di	13.50	68-C1ci	12.60	111-E2dk	14.75
26-E_b2ci	14.00	69-E1cj	12.25	112-E3ek	13.75
27-E_b2ei	13.00	70-E1dj	11.25	113-E3fk	12.75
28-B2ci	12.20	71-E1ej	10.25	114-D3ck	10.20
29-B2di	11.20	72-E1fj	9.25	115-D3dk	9.20
30-C2ci	12.03	73-D1cj	11.60	116-D3ek	8.20
31-E2cj	13.50	74-D1dj	10.60	117-D3fk	7.20
32-D2cj	10.20	75-A1ck	10.00	118-E_b3dk	13.00
33-B2cj	10.20	76-A1dk	9.00	119-B3ck	11.90
34-A2ck	9.63	77-A1ek	8.00	120-B3dk	10.90
35-A2dk	8.63	78-E1ck	13.25	121-C3ck	10.45
36-A2ek	7.63	79-E1dk	12.25	122-E3cl	13.75
37-E2ck	14.50	80-E1ek	11.25	123-E3dl	12.75
38-E2dk	13.50	81-E1fk	10.25	124-D3cl	9.20
39-E2ek	12.50	82-D1ck	12.60	125-D3dl	8.20
40-E2fk	11.50	83-D1dk	11.60	126-B3cl	9.90
41-D2ck	11.90	84-D1ek	10.60	127-B3dl	8.90
42-D2dk	10.90	85-D1fk	9.60	128-C3cl	8.45
43-D2ek	9.90	86-E_b1ck	12.00		

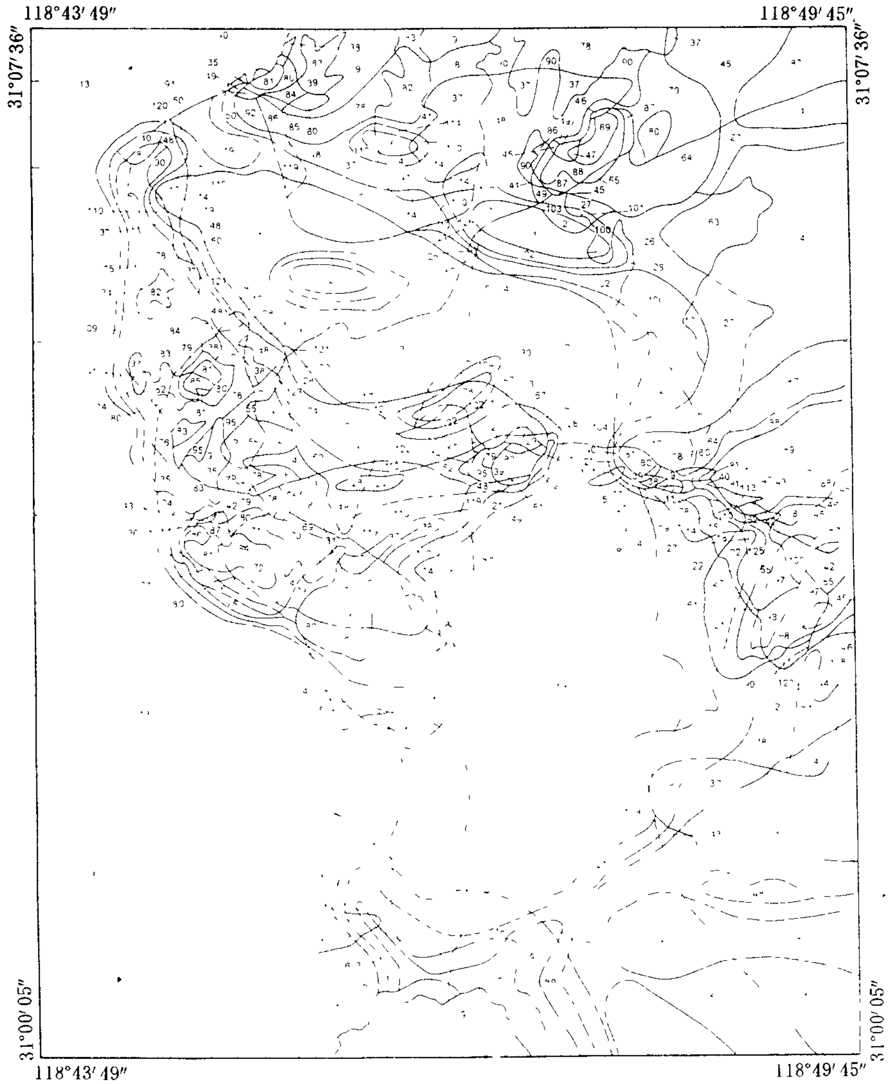

Fig. 5 The engineering geological conditions map of Nanjing city.

The map resuled from the compilation of those maps shown in Figures 1,2,3 and 4. The map is delineated into 128 geotechnical zones which are indicated by serial numbers. Each serial number refers to special ground model as shown in Table 3.

图5 南京市区工程地质条件图。

该图是由1,2,3,4综合分析所得,有128个标有数字的工程地质分区组成。每个数字指示表3中所示的各种场地模型。

Ⅰ. The average value of a Particular Physical Parameter (PPP) for each group have been obtained.

Ⅱ. The Optimum Average Value (OAV) for that particular parameter has given a Standard Rating Value (SRV) of five. Here, SRV actually corresponds to the number of the present groups after considering the Xiashu formation as one group, because they have identical physical properties. Later, the number of the groups is again completed to six after considering the stony behaviour of the cohesive clay in first order terrace.

Ⅲ. The ratio of OAV and the less quality value for PPP among the whole groups is calculated as a Folding Ratio Parameter (FRP).

Ⅳ. The Individual Rating Value (IRV) of PPP is calculated as SRV/FRP.

Ⅴ. The Total Rating Value (TRV) of each group is calculated by summation of the IRV of the whole physical parameters among each group.

Ⅵ. The TRV of each group is normalized to the SRV.

To introduce the stony cohesive clay into the rating list, the normalized TRV of non-bouldery cohesive clay is reduced by one. To satisfy the liquification condition of the infill channel deposits, and the inundation nature of the Yangtse river flood plain deposits, their normalized TRV have been also reduced by one.

Wiht regard to the soil thickness, the bearing capacity of each group is taken as rating criteria. For example, Since E, E_h and B have medium to high bearing capacity values as indicated from their higher E_s values, their medium and thickness ranges imply that they may be feasible for heavy foundations. On other words, no more excavation to rockhead. Accordingly, the thickness rating values will be reduced as the thickness ranges decrease. On the other hand, groups A, C, and D play an opposite role; for instance, due to their low bearing capacity, the lowest thickness range may be feasible and economic to excavate to rockhead as a foundation, and vice versa; that is, the highest thickness range the lowest rating value. Accordingly, the earlier highest geotechnical rating scores of E, E_h and B are given to the highest thickness range of each group as optimum rating value, whereas, the reverse is applied to A, C and D. Since four classes of thickness ranges have been adopted, each optimum rating value has been reduced by the factor of 0.25 successively (Table 1).

On the basis of textural, structural and lithological characteristics, bedrocks are rated into four classes. The land surface slopes already divided into four grades have been rated according to their hazard potential.

Summation of the rating values in each zone of multi-purpose map represents the step before the last in the construction of the foundation suitability map. One the basis of six rating ranges, zones of identical ranges have been delineated into five units. The higher rating range, the more optimum potentiallity of founddation. Notes on the distribution of the zones are given in Fig. 6, so that here only general comments will be made. The most obvious feature of the area is the ideal foundational condition of the cohesive clayey units in the western and the eastern part of the city. One the other hand, the Yangtse's flood plain and the middle N-S trending area of the paleochannel of Qinhuai river have the poorest potentiallity for foundational purposes.

5 Summary and Conclusion

The foundation ground conditions in urban Nanjing are determined by:

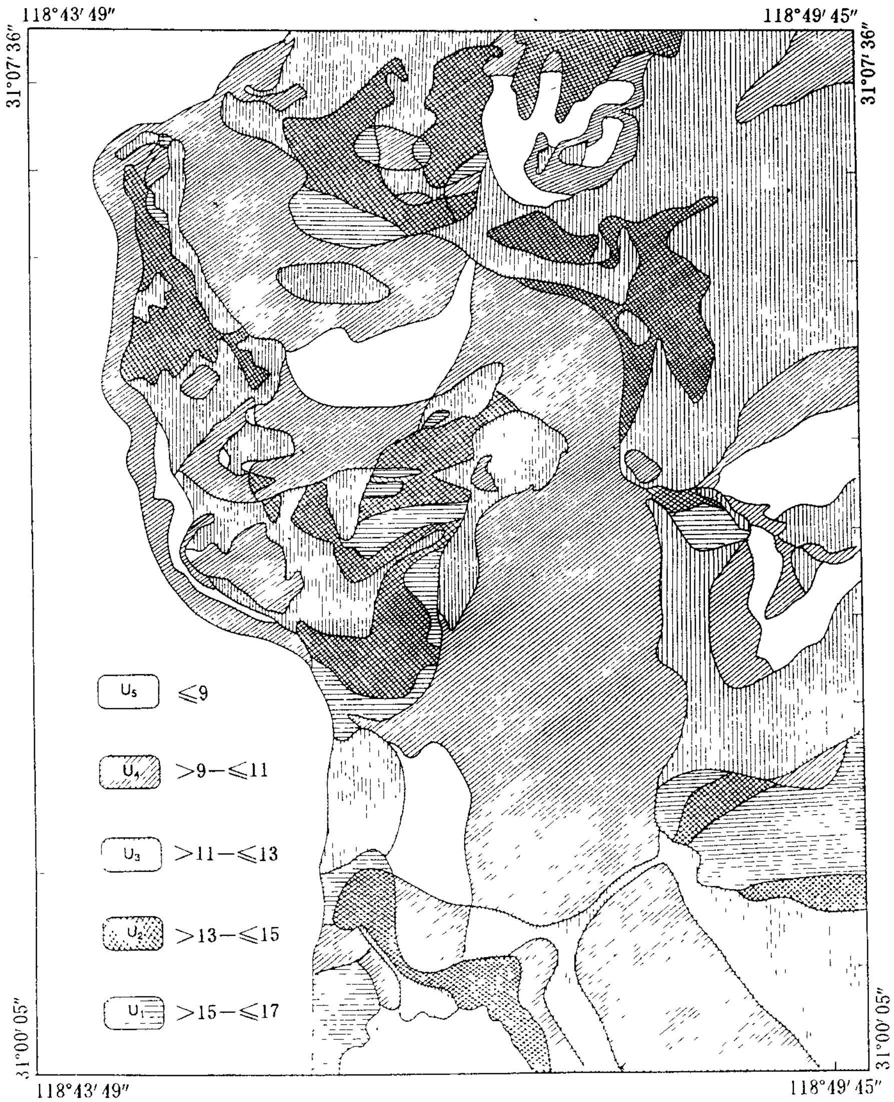

Fig. 6　The foundation suitability map of Nanjing city.

The five classes of ground conditions shown in the map are separated from the engineering geological condition map. The separation is carried out by summation of the rating scores of the fundamental engineering geological components of each zone, (see Table 3). The rating range of each class is indicated in the legend. The specification of these ground conditions are described in the conclusion of this text.

图 6　南京市区地基稳定性图。

图中所示的五级场地条件是从工程地质条件图得出的。通过每区的基本工程地质组分分级数累加所得(见表 3),每类分级范围如图例所示。这些场地条件的特性详见于本文结论部分。

1. variation in thickness of the general cover of Quaternary deposits, dominated by alluvial system infilled with more than 30m of superficial deposits.
2. The Pre-Quaternary bedrock conditions which mainly range from weak and permeable to

hard impermeable materials.

3. the geotechnical properties of the Quaternary sediments which range from low plasticity and low cohesion to high plasticity and high cohesion.
4. the topographic map in which the periphery and the central part is dominated by high mountains and low isolated hills, respctively. These areas have the highest slope gradient. One other words, they are most likely prone to the landslide than any other places within the city territory.

The resultant foundation suitability map is divided into five units.

These aggregated units are specified as (see Fig. 6) follows:

U_1 most suitable unit for all construction and development uses with no protection.

U_2 most suitable conditions for all construction with a low degree of protection (particularly against landslides).

U_3 most suitable for smaller kinds of construction; with a low degree of protection. In case of heavy and large kind of construction a moderate degree of protection is required against the relatively low bearing capacity of the overburden. No protection is required if the foundation is based on the underlying bedrocks.

U_4 most suitable conditions for smaller kinds of construction with a moderate degree of protection (particularly against the liquification and construction work). The bedrock represents the best base for heavy foundation. In such case the using of deep foundations requires additional expenses.

U_5 most suitable for light constructions; a ground condition requiring the highest degree of protection (e. g against flooding, construction work, low bearing capacity, liquification, etc). Bedrocks at greater depth, so, deep foundations seem to be extremely expensive.

It is necessary to note that the whole factors of the system (depth to the bedrock, slope gradient, bedrock quality and the engineering behaviour of the Quaternary soil) are involved in the comprehensive evaluation for the construction of the foundation suitability map. That is, these factors are assumed to be direct, important and to play the same role in a suitability assessment.

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南京市地基稳定性区划图

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摘　要　为了城市土地的合理使用，保证建筑物的安全，目前在城市岩土工程问题中对土地的合理利用研究和评价方法不断涌现。本文根据南京市的基岩岩性、地貌特征、覆盖层厚度和第四纪松散沉积物分布情况，对南京市区进行了工程地质研究并给出了相应切实可行的工程地质分区图，划分为五个基本类型，各个分区具有不同的工程地质特征。

关键词　边坡稳定性　地基问题　工程地质分区