Geoinformation database for installation of driving and boring piles in Astana

Nurgul Alibekova[1], A. Zhussupbekov[1], M. Mimura[2], and S. Akhazhanov[1]

[1] Department of Civil Engineering, L.N. Gumilyov Eurasian National University, 2, Satpayev Street, Astana, 010008, Kazakhstan.
[2] Department of Urban Management, Katsura Campus, Kyoto University, Kyoto, 615-8540, Japan.

ABSTRACT

This paper introduces the geoinformation database for installation of driving and boring piles in Astana city. Development geoinformation database and using it in various civil engineering projects largely depends on the accuracy of available borehole information as well as borehole distribution density. Borehole data are directly related to the specific location on earth surface thus development of borehole database system has more importance with the rapid development of computer technology. Geotechnical information system is not only borehole database, but are also able to handle various types and levels of geotechnical data. A lot of subsurface information is accumulated in urban areas, but such information is sparse in the case of developing and underdeveloped nation. Many countries are still struggling with borehole logs and geotechnical investigation reports written on a paper base. Recent increased advance in the information technology has greatly encouraged developing sophisticated digital geotechnical database. Geotechnical database plays a significant role to investigate the regional subsoil condition prior to detail investigation. The Geoinformation database can provide sufficient and helpful information, particularly for installation of driving and boring piles. The development of borehole database systems has become more important with the recent developments of personal computers and GIS technology. Objectives of this research is to develop the digital geoinformation system for Astana city.

Keywords: geoinformation database, engineering-geological conditions, driving piles, boring piles.

1 INTRODUCTION

The actual problem for today is the introduction of geoinformation database in the management of urban planning. The database development has focused in urban areas because of their social and economical importance. Geotechnical database plays a significant role to investigate the regional subsoil conditions prior to detailed investigation. The regional geotechnical characteristics can easily be grasped by the distribution of those soil properties. The Geo-database can provide sufficient and helpful information.

Currently, the practice of urban planning and control system of urban development activities require new approaches: in addition to the traditional form of urban materials necessary to form a modern control system design process, the functioning of state information and control systems and activities of local government. Since modern mass residential and industrial construction is organized in such a way that geotechnical investigations, development of building project, design bases and foundations, works on their device is performed by organizations poorly coordinating with each other. Their collaboration is governed only by the provisions of normative documents and other official documents, uniform throughout the country, which do not adequately enforced.

More than 2000 borehole data were collected. Basically, the information including soil classification, gradation, location, depth and coordinates of boreholes, NSPT and NDPT values, and groundwater levels has been entered in the geo-database. By using the geo-database, cross-sections of an area can be easily drawn over the computer screen, and soil parameters such as soil classification, gradation, the thickness of each ground stratum, groundwater level, NSPT values, etc. can also be readily known. The use was also made of the developed geo-database for assessing of the construction site and decrease expenses for carrying out surveys and design work.

2 GEOINFORMATION DATABASE FOR THE CITY OF ASTANA

The development of geoinformation database systems has become more important with the recent developments of personal computers and GIS technology. Borehole data are directly related to the specific location on earth surface thus development of borehole database system has more importance with the rapid development of computer technology. Geotechnical information system is not only borehole database, but are also able to handle various types and levels of geotechnical data (Alibekova, N.T. 2008).

2.1 Research of the engineering-geological conditions

The given program, includes for today data of 2000 boreholes, 402 points of static penetration and 125 points of dynamic penetration (Zhusupbekov, Alibekova et al., 2014) which has allowed to analyse regional conditions of soils before detailed research (Fig. 1).

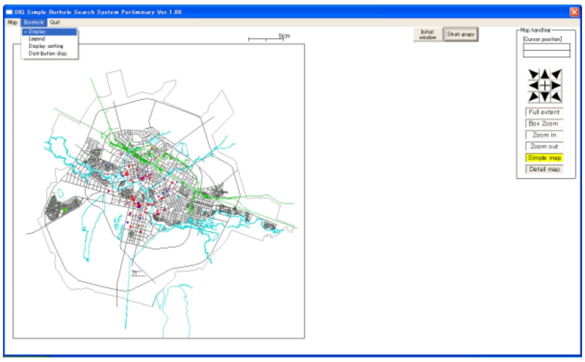

Fig. 1. Astana territory with the mapping of engineering geological boreholes and points of penetration testing.

To estimate engineering-geological conditions on the built-up territory of the city our Japanese colleagues of geotechnics and we (Zhusupbekov, Alibekova, Iwasaki et al., 2009) have created the first Geoinformation Database program based on the materials of geological engineering surveys on the projects of Astana city.

The program managed to examine the regional characteristics of soils up to a detailed study and solve the problem with rapid qualitative assessment of the territory of the future construction and reduce costs of design and survey as well as constructional work.

The area of Astana city is formed by soils different in their origin and age. There have been marked out six core engineering-geological elements (EGE) (Zhussupbekov A.Zh., Alibekova N.T. 2013):

EGE-1 - *anthropogenic deposits (t_{IV})* are presented by soil-vegetable stratum (EGE-1a) and filled soil (EGE-1b) (Fig. 2).

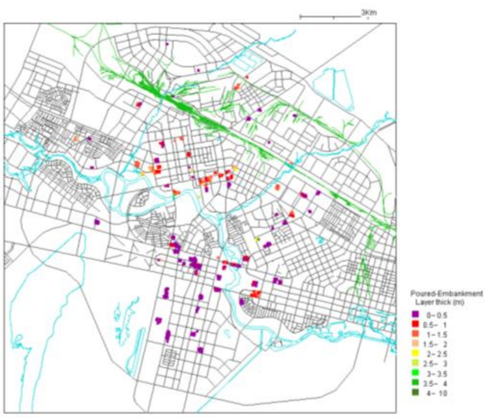

Fig. 2. Thickness of anthropogenic deposits.

EGE-2 – *alluvial medium-quaternary recent deposits (Q_{II-IV})* are presented by clay soils. It is formed mostly by loams (EGE-2a) with alternation of loamy sands (EGE-2b), clays (EGE-2c) and silts (EGE-2d) (Fig. 3).

Fig. 3. Thickness of alluvial clay soils.

EGE-3 – *alluvial medium-quaternary recent deposits (Q_{II-IV})* are presented by so-called sand-gravel formations, which consist mostly of sands of different size (EGE-3a) (Fig. 4), gravel sands (EGE-3b) (Fig. 5) and gravel soils (EGE-3c) (Fig. 6).

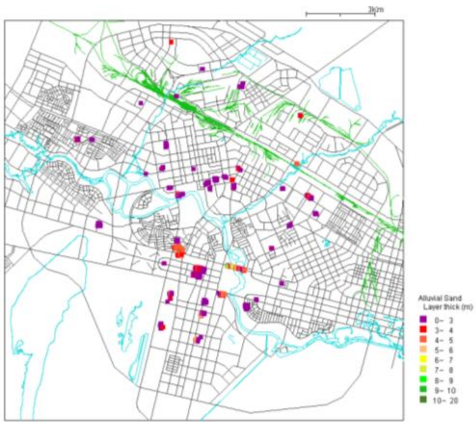

Fig. 4. Thickness of alluvial medium sand.

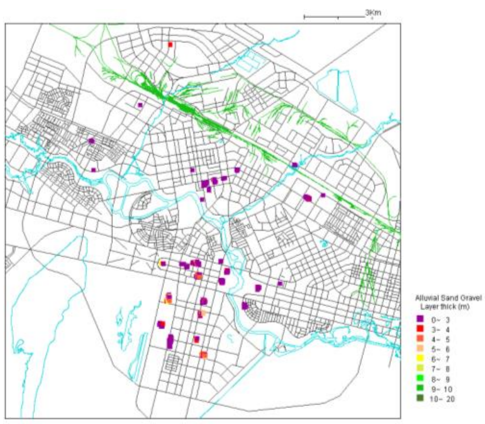

Fig. 5. Thickness of alluvial gravelly sand.

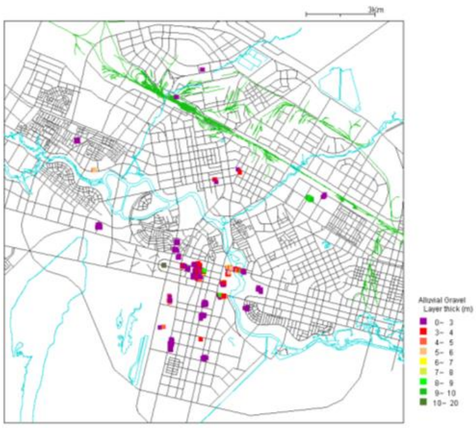

Fig. 6. Thickness of alluvial gravel soils.

EGE-4 are *eluvial formations of residual soil* $e(C_1)$, represented by loams and lentil clays with interlayers of loamy sands soils. The eluvial clay soils are found immediately below alluvial formation (Fig. 7).

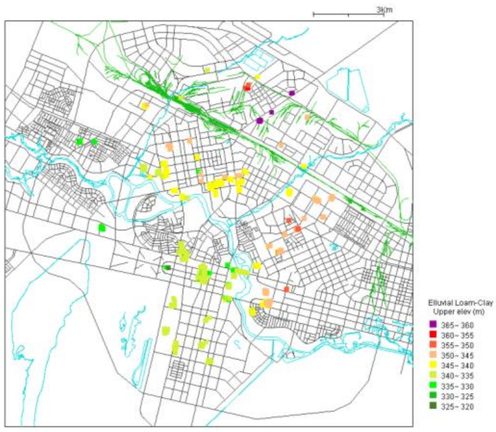

Fig. 7. Upper elevetation of eluvial clay soil.

EGE-5 are *eluvial formations of residual soil* $e(C_1)$, represented by breakstone soils (Fig. 8).

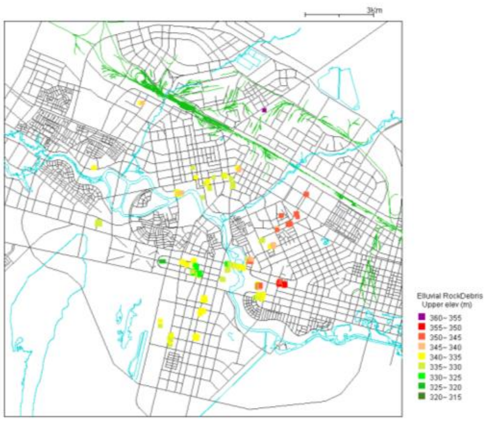

Fig. 8. Upper elevetation of eluvial rockdebris soil.

EGE-6 - *siltages of lower carbon* (C_1) are presented mostly by sandstones, which interleave with siltstones and mudstones (argillites) of the same age throughout its thickness (Fig. 9).

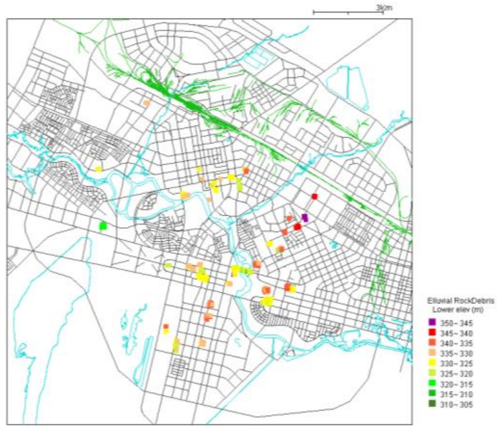

Fig. 9. Upper elevetation of rock soils.

2.2 Special geotechnical zoning maps for optimization length of driving and boring piles

The Geoinformation database program also helped (taking field data from similar engineering-geological conditions into consideration) to make a map of engineering-geological zoning for optimization length of driving and boring piles for the buildings of the 2nd (normal) level of responsibility, according to foundation types (Fig. 10), (Fig. 11).

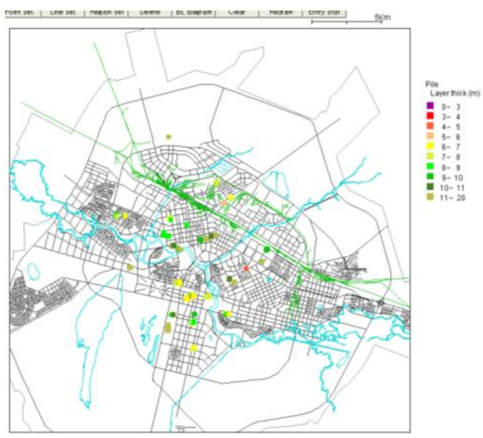

Fig. 10. Zoning of the territory of Astana for optimization length of driving piles.

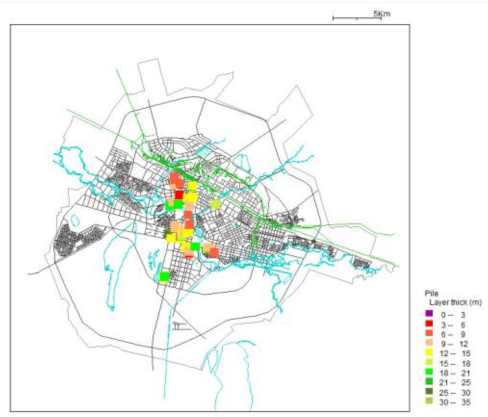

Fig. 11. Zoning of the territory of Astana for optimization length of boring piles.

3 CONCLUSION

This geoinformation database system allows the development of engineering and geotechnical maps on geotechnical zoning of the city according to the classification of soils and the criteria of homogeneity formed areas. The economic efficiency of a geoinformation system and developing engineering and geotechnical maps will significantly reduce the time and costs during the survey and design work, as well as in the construction of foundations for buildings and structures in difficult ground conditions. Implementation of geoinformation database ensures sustainable development of megacities, models and approaches in urbanistic development of geo infrastraktury megapolises and small cities of the new generation.

With the data results obtained, it can be noted that on the one hand developed software "Geoinformation database" and special geotechnical zoning maps to optimize the length of piles will promptly enable to obtain the necessary information for purposes of establishing the project works in construction and planning of city areas . On the other hand, the use of modern methods of information storage and processing will allow to optimization the engineering geological work and avoid duplication of work in the same area which will affect their quality and price.

REFERENCES

Alibekova, N.T. (2008). Engineering-geological conditions of Astana. IV-th Denisovskie readings «Problems of construction on ecological protection», Russia, Moscow, 151-154, (in Russian).

Zhusupbekov A.Zh., Alibekova N.T., and Morev I.O. (2014). Dynamic-penetration method for bearing capacity determination of precast piles, Soil Mechanics and Foundation Engineering, Volume 51, Issue 2, 100-104.

Zhusupbekov, A., Alibekova, N., Iwasaki, Y., Yamamoto, K., Komdo, K., Mimura, M. (2009). Research of geotechnical properties of soils in Astana. Proceedings of the International Scientific Practical Conference dedicated to the 45th Anniversary of the Tselinograd Civil Engineering Institute «Modern architecture, construction and transport: Situation and perspectives of development», Kazakhstan, Astana, 222-225, (in Russian).

Zhussupbekov A.Zh., Alibekova N.T. (2013). Geotechnical zoning territory of new capital Astana, Proceedings of the 4th International Conference on Geotechnical and Geophysical Site Characterization 4 (ISC-4), V.2, 1537-1542.