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Geotechnical geoinformation data base for the new capital city of Astana, Kazakhstan

Base de données géoinformation géotechnique pour la nouvelle capitale Astana, Kazakhstan

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ABSTRACT: Following its independence, the Republic of Kazakhstan has experienced rapid growth in many regions of the country. Perhaps the most prominent example of such growth is the development of the new capital, and megacity, of Astana. The efficient development of such megacities requires new methods for urban planning and regulation. When creating planning documentation for cities of all sizes, the use of various modern geoinformation systems contributes to efficient land use, proportional development of functional areas, optimization of the ecological state of urbanized areas, improvement and comprehensive performance of environmental organization for the civil infrastructure. This, in turn, reduces construction costs, improves re-organization of reconstruction areas in accordance with the quantitative indicators, keeps track of population changes and changes in industrial facilities, and helps ensure that their future operation takes place in a more reasonable fashion. This paper describes a geotechnical engineering based geographic information system (GIS) that has been developed to better manage the problematic soils found in and around the city of Astana, Kazakhstan. This geoinformation system is used to efficiently manage the construction of structures; it provides a relatively rapid assessment of the construction site and decreases the cost of geological surveys and thus foundation designs.

RÉSUMÉ: Après son indépendance, la République du Kazakhstan a connu une croissance rapide dans de nombreuses régions du pays. L'exemple le plus frappant de cette croissance est peut-être le développement de la nouvelle capitale et de la mégapole d'Astana. Le développement efficace de telles mégalopoles nécessite de nouvelles méthodes de planification et de réglementation urbaines.
Lors de la création de la documentation de planification pour les villes de toutes tailles, l'utilisation de divers systèmes d'information géographique modernes contribue à une utilisation efficace des sols, au développement proportionnel des zones fonctionnelles, à l'optimisation de l'état écologique des zones urbanisées, à l'amélioration et à la performance globale de l'organisation environnementale pour les infrastructures civiles. Ceci, à son tour, réduit les coûts de construction, améliore la réorganisation des zones de reconstruction conformément aux indicateurs quantitatifs, suit les changements démographiques et des installations industrielles et permet de garantir que leur exploitation future se déroule de manière plus raisonnable.
Ce document décrit un système d'information géographique (SIG) basé sur l'ingénierie géotechnique qui a été mis au point pour mieux gérer les sols problématiques découverts dans et autour de la ville d'Astana, au

Kazakhstan. Ce système de géoinformation permet de gérer efficacement la construction de structures; il fournit une évaluation relativement rapide du site de construction et diminue le coût des levés géologiques et donc de la conception des fondations.

Keywords: Geoinformation system; data base; geological surveys; foundation designs.

1 INTRODUCTION

Following its independence, the Republic of Kazakhstan has experienced a rapid development in the science and practice of urban planning and . Indeed, new methods for regulation of urban planning have facilitated the development of megacities and new capitals. Perhaps the most prominent example of such growth is the development of the new capital, and megacity, of Astana.

The 20th century has changed not only the approaches to the implementation of urban development activities, but also has provided new means and tools for creating project documentation. This includes the work of individual masters on creation of schemes for ideal cities, corporate decisions for general plans of cities and supersystems, and the problems of urban management environment.

Modern information technologies are used in areas of urban development activities such as urban planning, planning and building areas, architectural and construction design, and the creation of databases for urban planning.

The main tasks of information systems in the management of urban development consist of collecting, recording, storing, processing and providing information resources and reference information for consumers to make informed decisions on the placement, reconstruction and use of urban facilities in various stages of design. The use of information systems allows professionals to carry out continuous mixing functions, planning, spatial indicators and impact on architectural and planning organization through an objective assessment of demographic, economic, environmental and social processes, taking into account the interaction of socio-economic and urban development areas. Modern city planning and design management cannot function successfully without modern information technologies.

Creating planning documentation on the basis of information systems helps to improve the efficiency of land use, proportional development of functional areas, optimization of the ecological state of urbanized areas, improvement of the comprehensive performance of environmental organizations, and the developemtn of the infrastructure in residential areas.

This reduces the cost of expenses for achieving the standard indicators for the use and construction of territories, re-organized and reconstructed area qualitatively improved in accordance with the quantitative indicators development, and changes in the population and the number of industrial objects and forms their future operation takes place more reasonable.

Currently, the practice of urban planning and control system of urban development activities requires 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 is likewise important. Since modern mass residential and industrial construction is organized in such a way that geotechnical investigations, development of building projects, and foundation designs are poorly coordinated between participating organizations. Their collaboration is governed only by the provisions of SNIP and other official documents, which though applicable throughout the country, are not adequately enforced.

In some cases, after receiving survey information, designers change the location of structures for planning or architectural reasons. In such cases the geological engineering information is not entered into any sort of database. This, in turn, may lead to a decrease in the quality of design and to possible financial and employment expenses during the subsequent construction.

In addition, after the collapse of the Soviet Union, all organized system of collection, storage and delivery of materials for engineering surveys in Kazakhstan have largely collapsed. The State Archives of engineering survey have not been privatized by the state. Therefore, at present materials of engineering research in Kazakhstan remain in such archives. In many cases, these data are lost or are inaccessable. Consequently, important information about the conditions of occurrence of soils and their properties and possible changes over time is being lost. This situation not only complicates research, but also makes it unnecessarily expensive and lengthy. This is because of insufficient knowledge of engineering geological conditions in a given area, typically due to difficulties in implementation. This affects both current and planned construction and other economic activities.

Based on the above observations, the rational assessment of geological conditions without geoinformation technologies is very difficult, if not impossible. Such technologies typically make geologic data available in the form of maps and lists of properties. These, in turn, facilitate subsequent data analysis, modeling of geological fields in time and space, as well as other related information. In addition, the introduction of GIS technologies in the construction of the earlier stages facilitates the development of a common information base, both for research and developent activities as well as the management process associated with the construction of structures. This will tend to solve the problem of rapid qualitative assessment of the construction sites and will decrease expenses for carrying out surveys and design work.

2 THE CURRENT STATE OF DEVELOPMENT OF GEOINFORMATION SYSTEMS IN FOREIGN COUNTRIES

Beginning in the 20th century, geoinformation databases have been developed in foreign countries such as Japan, the USA, Russia, and other countries.

For example, in the archives of Helsinki (Finland) Department of Geotechnical Engineering, data are available for 20 thousand boreholes. Since 1903, such data have been developed on the basis of maps of Quaternary deposits and bedrock foundations of old buildings in Helsinki.

In Japan, geoinformation databases have a higher state priority. Since the 1950s, in the design of Japanese structures, attention has been given to the use of special engineering-geological maps that are based on a systematic collection of engineering and geological survey data. For example, the GIS database of the Kansai area, developed in 1966, currently contains data for more than 40 thousand boreholes (Fig. 1) (Geo-informatics for geological & geotechnical researches of Kansai Ground, 2005). The sponsors of this project are the state and arroximately 100 private companies.

In the present day Czech republic, in addition to engineering and geological maps, data corresponding to different stages of construction which contain information about the properties of soils, their filtration, strength, etc. have been recorded sonce the 1960s.

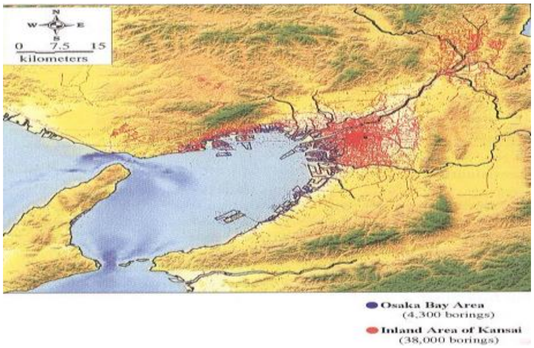


Figure 1 Location of wells in the area of Kansai

In 1966, the foundation of all modern geoinformation systems was developed at the computer graphics laboratory at Harvard University in the form of the SYMAP mapping system. This system became the foundation of all modern GIS systems. To date, geoinformation systems are being used throughout the USA, not only in geotechnical investigations, but also in other industries.

In Sweden, since the 1980s, engineering and geological conditions have been mapped for assessing the suitability of sites for construction and indirect economic evaluation. The existence of large-scale geotechnical zoning maps for the central part of Stockholm has provided information about the foundations of old buildings and their reinforcement. It has thus facilitated in the reconstruction of buildings, as well as in the development of a model methodology for calculating the zero cycle of works for the construction of new types of buildings.

In Russia, the creation of a geoinformation system is a very hot topic. For example, in the city of Perm, the program titled "Information systems in geotechnical investigations in the urban development" was established between 2010-2012. The aim of the program was to create an integrated information system for individuals and legal entities requiring a reliable source of data for the implementation of construction with minimal cost.

3 GEOINFORMATION SYSTEM FOR THE CITY OF ASTANA

In Kazakhstan, the program «Geoinformation Database» for materials from engineering-geological surveys in the city of Astana was created. This database provides a description of regional soil conditions that should be consulted before subsequently performing more detailed research (Fig. 2).

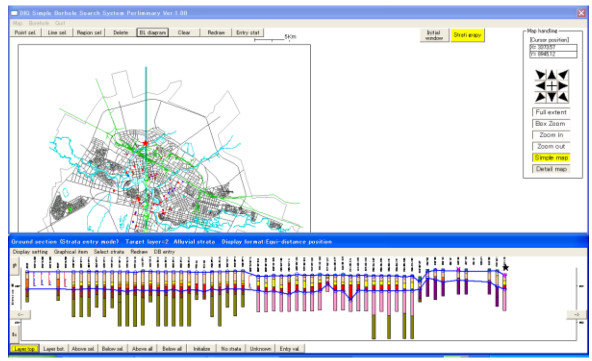


Figure 2 General view of the Geoinformation Database program

On the basis of this program, six core engineering-geological elements (EGE) have been identified (Zhusupbekov A., Alibekova N., and other, 2009), namely:

EGE-1 - Anthropogenic deposits (t_{IV}) consisting of soil-vegetable strata (EGE-1a) and fill soil (EGE-1b).

EGE-2 – Alluvial medium-quaternary recent deposits (Q_{II-IV}) consisting of clay soils. These are mostly formed by loams (EGE-2a) or loamy sands (EGE-2b), clays (EGE-2c) and silts (EGE-2d). There are sand lenses of different sizes (typically 1 - 3 cm, though sometimes up to 10 cm) throughout its thickness.

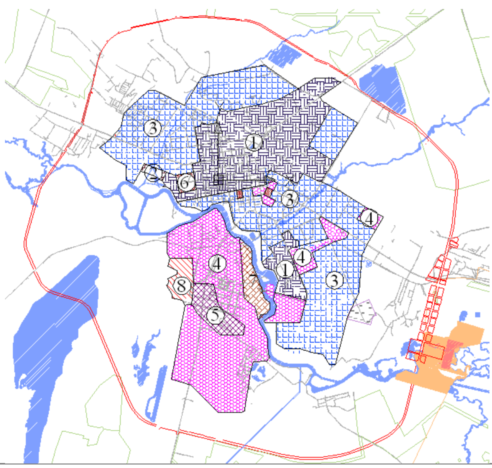
EGE-3 – Alluvial medium-quaternary recent deposits (Q_{II-IV}) are presented by so-called sand-gravel formations, which consist mostly of sands of different size (EGE-3a), gravel sands (EGE-3b) and gravel soils (EGE-3c).

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

EGE-5 - Eluvial formations of residual soil e(C_1), represented by breakstone soils.

EGE-6 - Silts of lower carbon (C_1), presented in the form of sandstones, which interleave with siltstones and mudstones (argillites) of the same age throughout its thickness.

The «Geoinformation Database» facilitated the creation of engineering-geological sections, maps of occurrence of Quaternary deposits and bedrock, and special geotechnical zoning maps by type base and optimizing the length of driven piles under the building 2 (normal) level of responsibility with regard to the type a base (Fig. 3 and 4) (Zhusupbekov A., Alibekova N. 2013).



1 type	2 type	3 type	4 type	5 type	6 type	7 type	8 type
EGE-1	EGE-1	EGE-1	EGE-1	EGE-1	EGE-1	EGE-1	EGE-1
EGE-2a	EGE-2d	EGE-2a	EGE-2a	EGE-2a	EGE-2a	EGE-2a	EGE-2d
EGE-4	EGE-2a	EGE-3a	EGE-3a	EGE-3b	EGE-2b	EGE-2b	EGE-2a
	EGE-4	EGE-4	EGE-3b	EGE-3c	EGE-4	EGE-3a	EGE-3a
			EGE-3c	EGE-5		EGE-3b	EGE-3b
			EGE-4			EGE-3c	EGE-3c
						EGE-4	EGE-4

Figure 3 Special geotechnical zoning maps by type base

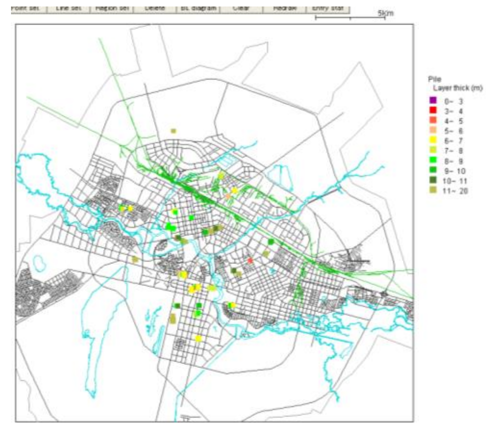


Figure 4 Special geotechnical zoning maps by optimizing the length of driven piles

4 PERSPECTIVES OF USING A GEOINFORMATION SYSTEM IN THE REPUBLIC OF KAZAKHSTAN

The development and implementation of geoinformation technology in the urban planning in the Kazakhstan will optimize future geotechnical work and will avoid duplication of work in the same areas. It will also quickly obtain the necessary information for purposes of designing structures in the construction and development planning in the city (see Table 1).

Table 1 - Comparative analysis on the type and timing of the works for the proposed (geoinformation system) and an alternative embodiment (engineering-geological surveys)

Type of work	**The proposed GIS**	**Alternative EGS (collection and analysis of the "paper" archive data)**
Drilling of the boreholes	-	-
Field tests	-	-
Laboratory works	-	-
Technical report	+	+
Period of execution, day	1	10

In addition, the aforementioned geoinformation system allows for the development of engineering and geotechnical maps for geotechnical zoning of cities according to the classification of soils and the criteria of soil homogeneity formed areas. It also facilitates the optimal design of foundations, based on the soil properties, type of loading, etc.

However, the dynamic growth of the database and geotechnical maps only increases with each new arrival of additional information. Therefore, a prerequisite for successful systematic solutions of various geotechnical problems associated with construction and operation of urban structures, as well as for continuous and systematic recording of all data on the state and dynamics of the geological environment, is the updating of the database through a suitable “geoservice”.

This geoservice will be responsible for the collection and processing of engineering material properties and geological surveys carried out in the city, to avoid duplication of work, to provide a rational approach for the composition and volume of research, and ultimately not only to reduce cost and time, but also improve their quality. Thus, before making a request of materials engineering and geological surveys for the projected construction site, then customer, together with geoservice, determines the composition and volume of work associated with the available materials.

Financing costs for the database can then be repaid in a relatively short time.

5 CONCLUSIONS

Implementation of a geoinformation database greatly facilitates the sustainable development of not only future megacities, but also small cities.

The economic efficiency of a geoinformation system and developing engineering and geotechnical maps will significantly reduce the time and cost of geological surveys and thus the subsequent design of foundations for structures in difficult ground conditions.

As a result, geoinformation databases should become an important tool for local authorities and businesses involved in regional planning.

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