Importance for Municipalities of Infrastructure Information Systems in Turkey

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Abstract **– Technical infrastructures are the important development-level parameters of countries, difficult to maintain and require high-investment cost. It is required to take the advantage of information system for the better administration of technical infrastructure facilities, planning and taking effective decisions. Hence, infrastructure information systems must be built oriented to technical infrastructure (TI).**

In this study, Kunduracilar Street in Trabzon was selected as pilot area oriented to urban TI studies. Graphic and attribute information of the pilot area were collected. Every TI facility was arranged into the same coordinate system with different layers. Maps showing TI facilities in the pilot area and 3D view of the site were prepared on ArcGIS software.

Keywords **– Municipal, Infrastructure information systems, GIS, 3D, Technical infrastructure.**

1. Introduction

Infrastructural facilities that are the basic requirements of urban life and the crucial parameters of development level are the important works of humanity since the first ages [1]. Utility maps showing electricity and telephone lines, water and gas pipes, sewer system are becoming important in Turkey. There is a need for both graphical and non-graphical data about those complex infrastructures to manage them effectively (Fig. 1.).

Figure 1. Representation of underground utilities of a city [2]

In this context, Technical Infrastructure (TI) maps are one of the main bases needed in Urban Information System (UIS) projects. In most municipalities, there is no graphical or non-graphical data about those utilities. Some municipalities have that information; however, they did not get the required standards [3]. Particularly, the locations of underground utilities are known approximately by old and experienced staff of municipalities and Associations and Institutions Related to Technical Infrastructure (TAIKUR). Therefore, digging and surveying works are needed to create the maps of those infrastructures.

A well-designed information system rests on a coherent foundation that supports modifications as new business or administrative initiatives arise. Known as the information system infrastructure, the foundation consists of core telecommunications networks, databases, software, hardware, and procedures. Managed by various specialists, information systems frequently incorporate the use of general information and telecommunication utilities, such as the Internet. Owing to business globalization,

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an organization's infrastructure often crosses many national boundaries. Creating and maintaining such a complex infrastructure requires extensive planning and consistent implementation to handle strategic corporate initiatives, transformations, mergers, and acquisitions [4]. Scholtenhuis et al. [5] (2016) presents a 4D CAD-based coordination method that supports project plan scoping, formalizing, and synchronizing. Contemporary applications regarding infrastructural facilities have been taken under the information system. Scheu and Philipp [6] (2015) mainly focus on how a posteriori implementation of Digital Cadastral Maps can be done describing necessary steps and methods. Kulawiak and Lubniewski [7] (2014) present a system for the analysis of municipal critical infrastructures, which offer integrated tools for target analysis, hazard scenario simulations, and spatial analysis within a remotely accessible Web-based GIS. Du et al. [8] (2011) studied the 3D visualization of pipelines organized as 3D lines in a DBMS. Parameters, such as diameter, heights, radius, are organized together with the pipe geometry as well. They are performed on a case study area of Yibing city, Sichuan Province, P.R. China and experimental data set of the Netherlands. He et al. [9] (2011) mainly focus on the design and implementation of underground pipeline 3D visualization and layout optimization based on the 3D digital city. They explain a set of techniques for the pipeline layout optimization and simulation, and provide decision support for urban underground resources management, pipeline planning, and urban planning. Coutinho-Rodrigues et al. [10] (2011) present a decision support system aimed at offering the users (e.g., government or municipal agencies) a flexible and user-friendly environment to provide decision aid in urban infrastructure planning. Shaheen and Rehman [11] (2014) and Lu[12] (2011) analyzed the characteristics of the data of gas pipeline network to improve the efficiency and operation efficiency of gas pipeline network information management and the implementation of GIS for the country's gas network. A study covering infrastructure information systems (INIS) that has been performed by Maze et al.[13] in 1998 has been applied in many local administrations in US. They have developed an interface design covering INIS activities for the requirements of local administrations innovated by the support of US Department of Commerce Economic Development Administration. With the help of this information system about the citizens of that area, infrastructure plan data, road information, and wastewater contract information can be inquired.

2. Technical Infrastructure Studies in Turkey

In Turkey, in the study conducted by Kursun, Bektas, Yılmaz, and Tuncer in [14] 2001, research on the probability of INIS that have been formed within Istanbul Gas Distribution Inc. Co. (İGDAS) has been made. IGDAS targeting to establish a broad service network regarding natural gas to whole Istanbul that is continually growing and developing has stated to use present natural gas facilities more efficiently, securely and controlled and to access any kind of infrastructure information more quickly, the studies for Geographical Information System Project have started since 1995, and they have saved 98% of infrastructure lines in computer and paper media, in UTM system, and the maps are being saved under the same standards. IGABIS, the first INIS in Turkey, is an information system covering automatic map generation, generation, modeling, analysis, monitoring and inquiry of linear network and connections in computer media, customer services and facility management. This project aims the operation of Address Information System, Equipment Management System, Network and Risk Analysis Systems in harmony with Management Information System, Mobile Office System, SCADA, AS400 Customer Information Systems of IGDAS and ISKABIS in other institutions and Urban Information System Projects of Istanbul. In the further phases of the project, also by publishing graphical and verbal information over the internet or intranet, it is aimed that customers access these information more quickly and in more accurate way and that updating is made online.

In this respect, other INIS that is actively used in Turkey is Infrastructure Information System of Water and Sewerage Administration of Istanbul (ISKI). ISKABIS is a GIS project that has been started in August 1999, targeting renewal of current system in terms of software and hardware. This renewal aims at more quick data entries and network integrity. Also, it aims to perform any kind of GIS analysis, and functions such as modeling and scenario management, thematic (topical) map generation, etc. [15].

Also, the arrangements and studies that are performed by Petroleum Pipeline Corporation (BOTAS) and Energy Market Regulatory Authority (EPDK) have contributed much in the establishment of INIS and generalization of the use. BOTAS was established on August 15, 1974, to transfer Iraqi oil to Ceyhan, as being a partnership that is bound to Turkish Petroleum Corporation (TPAO). By 850 km Malkoçlar main transmission line that has been taken into operation after being completed in 1988, natural gas transmission process was started [16]. With, as of September 2015, 12.812 km of natural gas pipeline

of BOTAS and with the help of 69 private firms with distribution license given by EPDK to distribute the natural gas to the cities; natural gas is used in 77 of 81 cities as of October 2015 [17]. (Figure 2).

Figure 2. Natural Gas and Crude Oil Pipelines in Turkey [18].

Today, with the widespread use of natural gas all over Turkey, natural gas is supplied to nearly 11 million houses as of January 2015 [19]. EPDK requests from natural gas firms that are authorized for natural gas distribution in the cities , the establishment of natural gas INIS, prescribed by regulation. With the help of this, the establishment of INIS in TI institutions of Turkey will be supplied more prevalently.

In the second half of twentieth century, which is a rapid living and build-up age, people required more heating, lighting and water with technology like in other life factors [20]. However, the increasing demand for infrastructure with rapid and irregular urbanization in Turkey has not been met. To live in a city humanly and in contemporary way, a contemporary house, sufficient water, electricity, sewerage, a tidy environment, natural beauties, and so on, are required. To achieve this, the administrators of the cities that will make political and economic decisions, planning and implement these decisions and plans must have all information regarding that city [21].

However, this information, as a matter of the urban structure, is scattered in limited number within separate professions. These data are preserved in media such as paper, index, card, etc. in traditional systems. This classical approach is not adequate for processing, storing, updating, analyzing, and introducing the data [22].

In order to take TI of a city under control (natural gas, electricity, drinking water, wastewater, telephone, etc.), solving the problems, providing planning and coordination, making healthy and rapid decisions are not possible with the current system opportunities. These realities have introduced the requirement of forming "information management" and "management mechanisms" to solve the problems of local administrations. To own the city, the administrators have inquired the formation of information system for themselves [22].

Spatial, attribute, and function information of technical infrastructure facilities (TAT) in our metropolis and other cities are generally stored in information, and the memory of the staff who have previously worked or still works in that region. Because of this, in case of breakdown and repair of the facilities, using the knowledge of masters who have retired from that business is a method that is frequently used. The fact that reliable, accurate, graphical and attribute information and documents related to TI facilities are not handled by the operators, make operating activities of these facilities harder, increase construction costs. Demands and complaints from the customers in these subjects make administrators hard up; and cause unplanned-unscheduled investments and expenditures that will salvage the day of the administrators [23]. Thus, the necessity to form a healthy data infrastructure and INIS emerges. By forming an INIS that will generate solution to the so-called problems in this study and the results gathered from a sample survey field will be mentioned.

3. Case Study

In this study, an application is made in a pilot region that will be footing for INIS. In order to do this, in Kunduracilar Street that is within Kemeryaka Ward in Central district of Trabzon city by determining infrastructure facilities composed of electricity, water, sewerage and telephone the positioning is made, and these are arranged in separate layers (Fig. 3.).

Figure 3. Study Area

The following factors were considered for the selection of this region:

1. Kunduracilar Street is one of the oldest streets of Trabzon, and it reflects traditional street type of Trabzon. Most of the buildings around the street are historical buildings and they are brought to infrastructure according to contemporary developments.

2. Cultural attribute that historical Silk Road reaching Trabzon from Central Asia ends at ancient port in Moloz locality by following this route [24] .

3. Trabzon has always been an important trade center, so it is a street showing the intensity of trade in commercial life of the city.

4. By-streets and infrastructure facilities in these streets pass from this street.

5. With infrastructure facilities that are added in 2004 lastly, by digging the street once more, all the facilities are taken underground and road superstructure is rearranged, because of this, there is an extremely complex infrastructure facilitation under the floor.

6. Since natural gas facility is not considered during the last arrangement, re-digging of the roads for these facilities in the close future is inevitable, and this causes a big burden,

7. Because of all these features, Kunduracilar Street indicates a structure that reflects old and new features of Trabzon [3].

4. Methods

For the design of the system, the following steps were taken:

- Review of the literature related to infrastructures management systems.
- Definition of the system: To determine the existing conditions and requirements for the system, the activities, human power, workflow, organizational structure, problems.
- Design of the system: Settling and organization plans were prepared, and system, data, operation, and physical design (database design, preparation of data dictionaries, data collection) were made in parallel to each other.
- Software development: The final step is the implementation of the system using a database management system and front-end software package. It is known that no GIS can meet the institutional requirements exactly so a flexible design of the interface will increase the longevity of the system. The development of GIS is aimed to bring this electronic environment to broader masses. GIS software packages can be very difficult-to-learn and use for administrators, researchers, lecturers and students because of their complex structures. Operating the whole system requires professionally qualified experts. Software development to the ease of use in GIS software packages is especially necessary [25].
- Application of developed system for the study area.

4.1. Data Collection

In the study, data collection is implemented under two titles, namely collection of graphical and verbal data. Database layers and attribute information were determined according to the application region (Table 1.).

Present maps, graphical information of all of natural and artificial information present within the administrative borders of Trabzon municipality that has been implemented in 1999 by Provincial Bank are obtained in digital media. Cadastral Maps and information regarding the Zoning Plan of zone application are obtained from the Trabzon Municipality in digital media. Later by converting into DXF format, in ArcGIS program, then converting into SHP file format on which it will enable making changes, polygon topology is established.

Table 1. Layers and attributes' information

Layer	Layer Type	Layer Name	Fields	Source	Scale
House	Polygon	House	Shape, B_Geocode, Bina_id, Alan, Cevre, Bina_adi, Bina_yapi_cinsi, Kullanim_amaci, Kapi_no, Kat_adedi, Daire_sayisi, Isinma_sekli Mah_kodu, Yol_kodu	Cadastre Maps	1/500
Cadastre	Polygon	Cadastre	Shape, Kadastro_id, k_code, Il, Ilce, Mah_kodu, Yol_kodu, pafta_ada_no, parsel_no, Alan, Cevre	Trabzon Municipality	1/1000
Plan	Polygon	Plan	Shape, i_geocode, Imar_id, Ada_no, Yapi_nizami, Kullanim_turu, Kat_adedi, TAKS, KAKS, cnbahce, arkabahce, yanbahce	Trabzon Municipality	1/1000
Road	Line	Road	Shape, Uzunluk, yol_id, Kaplama_cinsi, Yapim_yili, Onarim_yili, Serit_sayisi, Genişlik, Mah_kodu, Yol_kodu	Base Maps	1/1000
Telekom Line	Line	Telekom Line	Shape, Hat_id, Hat_no, Bas_zemin_kotu, Bitis_zemin_kotu, Bas_hat_kotu, Bitis_hat_kotu, Uzunluk, Goz_sayisi, Yapi_cinsi, Yapim_yili, Yapimci_firma, Kablo_cinsi, Mah_kodu, Yol_kodu	Telekom Land Survey	-
Electric Line	Line	Electric Line	Shape, Hat_id, Hat_no, Bas_zemin_kotu, Bitis_zemin_kotu, Bas_hat_kotu, Bitis_hat_kotu, Uzunluk, Yapimci_firma, Yapim_yili, Onarim_yili, Kesit_cinsi, Gerilim, Faz_sayisi, Gecis_yeri, Zemin_cinsi, Mah_kodu, Yol_kodu	Land Survey	-
Water Line	Line	Water Line	Shape, Hat_id, Hat_no, Bas_zemin_kotu, Bitis_zemin_kotu, Bas_hat_kotu, Bitis_hat_kotu, Uzunluk, Yapimci_firma, Yapim_tarihi, Onarim_ yili, Boru_cinsi, Boru_capi, Mah_kodu, Yol_kodu	Land Survey	-
Sewerage Line	Line	Sewerage Line	Shape, Kanal_id, Kanal_no, Bas_zemin_kotu, Bitis_zemin_kotu, Bas_hat_kotu, Bitis_hat_kotu, Kanal_egimi, Uzunluk, Cinsi, Capi, Yapimci_firma, Yapim_yili, Onarim_yili, Mah_kodu, Yol_kodu	Land Survey	-
Telekom Manhole	Point	Telekom Manhole	Shape, Menhol_id, Menhol_no, Zemin_kotu, Menhol_tipi, Yapi_cinsi, Goz_sayisi, Boru_sayisi, Lokal_cikis, Menhol_yeri, Yapim_yili, Yapimci_firma, Kablo_ek_yapan, Kablo_ek_tarihi, Mah_kodu, Yol_kodu	Telekom Land Survey	-
Telekom Box	Point	Telekom Box	Shape, Sahadolap_id, Sahadolap_no, Sahadolap_kotu, Kapasite, Doluluk, Yapim_yili, Mah_kodu, Yol_kodu	Telekom Land Survey	-
Electric Box	Point	Electric Box	Sahape, Elkbox_id, Elkbox_no, Faz, Gerilim, Abone_sayisi, Yapim_yili, Mah_kodu, Yol_kodu	Land Survey	-
Lighting	Point	Lighting	Shape, Aydinlatma_id, Aydinlatma_no, Zemin_tatli_kotu, Direk_cinsi, Yapim_yili, Lamba_ozellik, Yeri, Ampul_sayisi, Mah_kodu, Yol_kodu	Land Survey	-
Fire valves	Point	Fire valves	Shape, Yanginvana_id, Yanginvana_no, Zemin_kotu, Yapim_yili, Mah_kod, Yol_kodu	Land Survey	-
Water valve points	Point	Water valve points	Shape, Suvana_id, Suvana_no, Zemin_kotu, Yapim_tarihi, Bulundugu_yer, Durumu, Mah_kodu, Yol_kodu	Land Survey	
Water	Point	Water	Shape, Sukor_id, Sukor_no, Zemin_kotu, Zemin_alti_kotu, Mah_kod, Yol_kodu	Land Survey	
Cannel-chimney	Point	Cannel-chimney	Shape, Baca_id, Baca_no, Zemin_kotu, Akar_kotu, Kapak_tipi, Capi, Yapimci_firma, Yapim_tarihi, Onarim_yili, Bulundugu_yer, Durumu, Mah_kodu, Yol_kodu	Land Survey	-
Address	Text	Address	Mahalle_adi, Mahalle_kodu, Yol_adi, Yol_cinsi, Yol_kodu	Trabzon Municipality-TUIK	-

Present maps, graphical information of all of natural and artificial information present within the administrative borders of Trabzon municipality that

has been implemented in 1999 by Provincial Bank are obtained in digital media. Cadastral Maps and information regarding the Zoning Plan of zone application are obtained from the Trabzon Municipality in digital media. Later, by converting into DXF format, in ArcGIS program, then converting into SHP file format on which it will enable making changes, polygon topology is established.

In the application made in Kunduracılar Street, in gathering of spatial information and information, documents obtained from institutions and information given by staff of these facilities are used. By using these data, the places of the facilities are determined and making on the ground is made. Spatial information of marked places is desired to be measured by GPS that is the developed measuring technology of our day, but since buildings on both sides of the street block monitoring GPS receivers from sufficient number of satellites, this measurement could not be done. Because of this, spatial information is generated by terrestrial method and as three-dimension by using total station. Here, the spatial sensation of the facilities is at the rate of accuracy of data that are gathered from the institutions [3].

Maps showing infrastructure facilities that are present in application zone are arranged separately. Map showing all the TI lines in application zone is prepared (Fig. 4.). Map showing electrical facilities is given in Fig. 5., water facilities in Fig. 6.

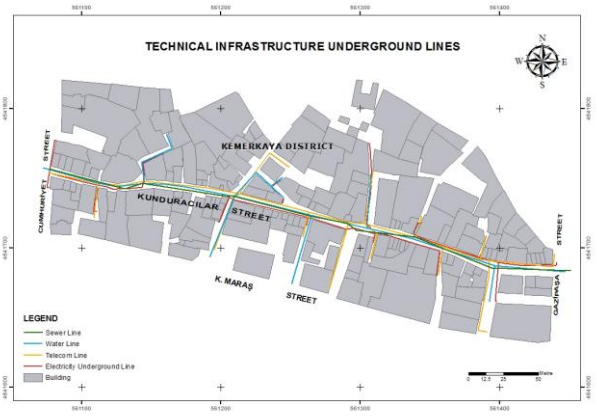

Figure 4. Technical infrastructure underground lines

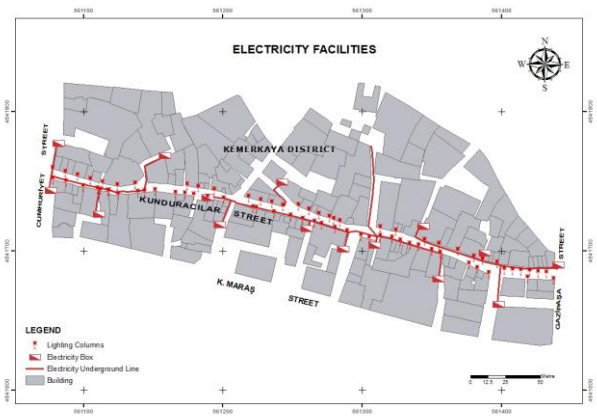

Figure 5. Electricity facilities

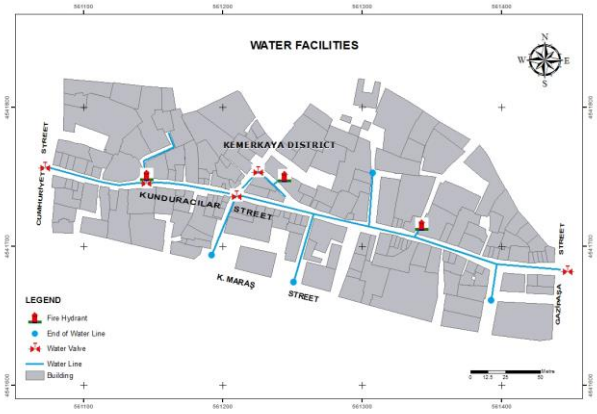

Figure 6. Water facilities

With the aim of making necessary analysis and inquiry on road network, road network is formed from central-axis of road on the present map lineally. Later, this line has formed the topology of the featured road layer, by entering road information into related columns (width, number of lanes, type of cover, construction date, etc.) it is formed in road database.

By taking layer of contour lines showing topographic structure of application zone from present maps that are digital, it is converted into DXF format. Later, it is converted into SHP file format by ArcGIS program. 3D land model is monitored by using ArcScene module of ArcGIS program.

Attribute information of infrastructure and superstructure construction facilities of survey zone is gathered from the related institutions and in amount that can be found from the land. However, this information is inadequate in forming attribute tables for inquiry and analysis. Because of this, attribute tables are prepared by derived information.

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4.2. Database Design

Database designing is the sum of the operations or abstracts research objects from the real world to the information world; such as definition of the objects, evaluating alternative approaches by reproduction, analyzing and displaying work plan. Database design can be examined in three parts as Conceptual Design, Logical Design and Physical Design [25].

Study matrix and data vocabulary introducing aim, target of the project and database design are shown in Table 2. As seen in Table 2., relational model has the greatest advantage. The relational model is not only the most commonly used data model in database, but also an effective data organization approach to build relationships between spatial data and attribute data.

Table 2. Database files and layer design matrix

Aim	Goal	Function	Application Tools	Production Maps	Query Analyses	Data Layers
Creating an infrastructure Information and Management Information systems	Infrastructure project data system					K1, K2,...
	Integration of subscriber information system					
	Integration of address information system					
	Integration of other information system					

AIMS AND GOALS MATRIX

Layers	Data	Data Type	Data Structure	Data Source	Data Setting	Character Width
K1	Code	Integer	Polygon	Land Survey	x	15
K2						
..						

5. Results

In this part, inquiry, analysis, and interface design samples regarding some applications related to infrastructure are given. These sample applications will form the basis in solving problem and designing within the scope of INIS in Turkey.

In the first example, an application for finding which buildings will be impacted in case of a water or power cut for any reason. With the help of this, citizens residing in the buildings, water and power of which will be cut and informed by communication tools (Fig. 7. and 8.).

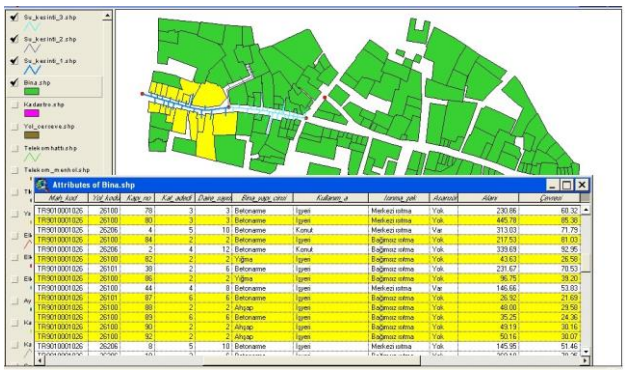

Figure 7. Areas affected by water cut

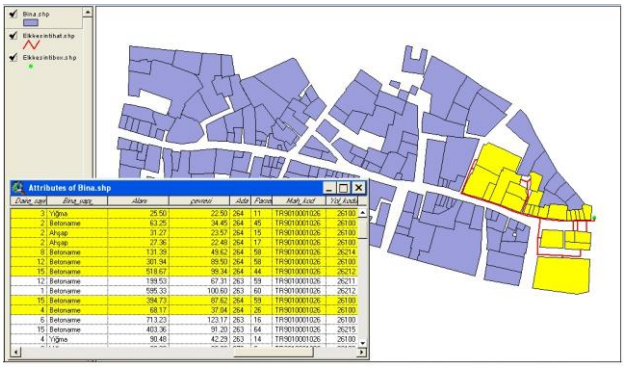

Figure 8. Areas affected by power outage

In the second example, it is determined which infrastructure lines will be met, for example as an area with the diameter of 2 meter is dug for an infrastructure study. Over these lines, inquiries can be made and what kind of measures must be taken during digging are determined. Here, a sample is made for telephone line (Fig. 9.).

The municipalities gain water and sewerage mounting amounts for equipment and labor as the result of the labor of connecting sewerage and water line in streets and alleys to buildings from the owners of the buildings. While performing these, ground destruction is the problem, excavation is made, and assembly is made between immovable and the line. Because of this, to remove ground destruction and demolishment, it is necessary to know the required area. For soil excavation and filling, the calculation of the volume and for assembly the length must be known. In the third example, interface design is made in ArcGIS program with this aim. Therefore, measurements can be determined without going to the field and according to this labor, excavation, ground destruction, and repair charges can be taken (Figure 10.).

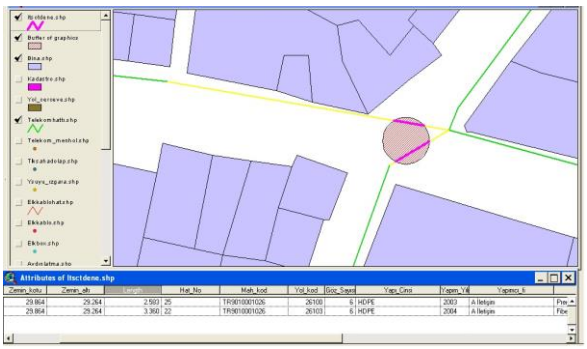

Figure 9. Areas affected by power outage

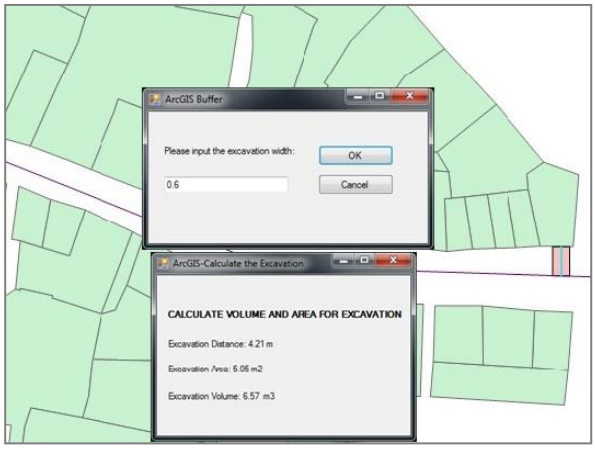

Figure 10. The sample calculation for the excavation area

In projecting and application of infrastructure studies, it is required to have the longitudinal section of the land. Especially since sewerage and rain-water canals are projected and applied according to attractive flow, altitude information of the land gains more and more importance. Here, by using profile tools gained by making interface design within ArcGIS program, longitudinal section of Kunduracilar Street is made.

6. Discussion

The bases of spatial information systems is composed of spatial information and attribute information that is bound to this and are crucial in terms of time and cost. Using these systems in different applications, in decision-support process in a secure way depends on the fact that the information is healthy and updated.

The main problem in TI studies in Turkey is that spatial information of present infrastructure facilities is not healthy and updated. Because of this, during TI studies previous infrastructure facilities can be damaged. Urban planning cannot be implemented healthily, even when it is done it cannot be applied and managed properly and coordination cannot be provided in desired figures among TI institutions. Therefore, as environmental issues that emerge, living quality decreases. In order to prevent this, a legal obligation must be brought for as-built (end of the work) plans, showing final figure of the facilities from associations and institutions establishing and operating TI facilities. In construction phase, tender specifications must absolutely be arranged and in the specifications the obligation of employing surveying engineer must be included and a portion of amount of the tender must be paid after gathering spatial information of TAT and their controls are provided.

During the construction of new infrastructure facilities in the cities, other infrastructure facilities that will emerge by digging of streets and alleys, will be determined by being measured by a unit that will be established with the support of technical staff of related institutions and gathering of spatial information of present infrastructure facilities can be solved as far as possible. Because of this, particularly in last years, digging of streets and alleys for natural gas works must be exploited accurately. Therefore, studies for gaining spatial information of current TI facilities are deemed to be made. In this issue, Infrastructure Coordination center (AYKOME) that is present in metropolitan municipalities must play an active role.

In establishing infrastructure information system in Turkey, with the fact that Associations and Institutions Related to Technical Infrastructure (TAIKUR) have efforts, it is understood that studies are not adequate. The main reasons that INIS are; there is no healthy and updated spatial information of TAT, lack of expert staff and that the importance of the work that is performed cannot be fully understood. In order to achieve this, information about the importance of positional information and benefits of INIS must be told to executive staff of TAIKUR and establishment of infrastructure information system must be made obligatory. In fact, with Metropolitan Municipality Code with the number 5216 and Municipality Code with the number 5393 among the missions and authorities of all the municipalities, establishment of urban information system is mentioned. Because of this, in the pioneering of municipalities, other TAIKUR must support effort of establishment of INIS. Source and expert staff support that is required for this must be provided.

In order to obtain 3D spatial information of TAT according to Regulation on Large-Scale Map and Map Data Production to make rapid and healthy decisions in cases related to these facilities, establishment of an active INIS covering 3D information/data is required. In order to achieve this, graphical and attribute data standard related to TI facilities must be formed in detail.

At the top of the difficulties met in pilot study performed regarding the presentation of information hat may be footing for INIS within the scope of the

study, we see the lack of information about TI facilities. Rearrangement of road superstructure of application zone has caused that some buildings that must have been at the surface of TI facilities to be below as a result of being covered. Therefore, it has been necessary to use the knowledge of the staff worked in the construction of TI facilities. When it is not possible to access these people, the problem becomes more complex. The sensation of spatial information of TI facilities that are arranged in this figure is a crucial problem.

7. Conclusion

For urban management to make more contemporary, rapid, and economic decisions and give services, infra- and super-structure information of the city are needed. For the urban life to be contemporary and qualified; proper operation and continuous serving of TI of the city is necessary. Urban infrastructure facilities will become more crucial in the future. For example, it is expected that the demand for water that is on the agenda with the impact of global heating will increase more in the coming years. Because of this, handling of infrastructure facilities and facility management with a new approach has gained importance.

Within the scope of this study, the study is made in a pilot region that will be footing for INIS. TI facilities that are present in application zone are determined, spatial information is gathered, and by making database design, TI maps are formed. By forming 3D land model of survey filed from these maps, infra- and super-structure facilities are monitored. With the study, the opportunity of rapid access to TI facilities in maintenance, repair, and faults is provided. Thus, planning and coordination will be provided in a better way. In construction, maintenance and repair of TI facilities, and damage to other facilities will be minimized. In the application, for example, for using in calculation of mounting amounts of water and sewerage, interface design is made in ArcGIS program. Therefore, charging is made by calculating digging area and volume.

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