Using Geographic Information System (GIS) to Manage Civil Engineering Projects

Asmaa Abdul Jabbar*

Received on: 31/10/2010
Accepted on: 7/4/2011

Abstract

Geographic Information Systems (GIS) have been used in many fields of Science; one of these fields is civil engineering. Geographic Information System (GIS) is a computer based tool used to solve engineering problems related to spatial data. GIS, its complete potential to construction industry has not been realized. GIS technologies have the potential to solve space related problems of construction involving, integration of information, urban planning, and project site selection, soil studies, Hydrology and environmental studies. Proper use for these tools necessitates training the GIS techniques.

لادارة مشاريعِ الهندسة إستخدام نظم المعلومات الجغرافية (GIS)المدنية

الخلاصة

نظم قواعد المعلومات الجغرافية (GIS) استعملت في العديد من حقولِ العلْمِ . إحدى هذه الحقولِ الهندسة المدنيةُ. نظم المعلومات الجغرافية (GIS) اداة تستعمل لحل المشَاكل الهندسية المتعلقة بالبيانات والمعلومات المكانية وقابلية تحليلها واستخدامها في عملية تخطيط وتصميم وتنفيذ المشاريع . استخدام نظم المعلومات الجغرافية وامكانيته في الاعمال االهندسية لَم يستثمربصورة كاملة لحد الان بالرغم من الامكانيات الهائلة لنظم المعلومات الجغرافيةُ لحل المشاكل والصعوبات المتعلقة بالاعمال الهندسية من تكامل المعلومات لإختيار موقعِ مشروع, دراسات تربة ، دراسة موارد مائية ودراسات بيئية . الإستعمال الصحيح لهذه النظم وتطبيقَاتها يستوجب التدريب على تقنياتها ومعرفة جيدة في ادارة وتنظيم وتوظيف هذه المعلومات للحصول على افضل النتائج.

Introduction

There are many fields in civil engineering where GIS is being employed as a tool to analyze, design, and implement effective and efficient solutions. GIS functionalities have been used to assist in the analysis, selection, prioritization, and implementation of civil engineering projects. In this regard, many GIS applications have been developed in hydrology, hydraulics, water resources, transportation, geotechnical, surveying, environmental and other fields of civil engineering, to facilitate engineering analysis, modeling, design, implementation, management, Decision making .GIS is a computerized database management system that provides geographic access (capture, storage retrieval, analysis and display) to spatial data. GIS provides an excellent means for civil engineer to manipulate and examine the complex data usually required in the design and analysis processes. As a result, civil engineers work with a

*College of Engineering, University of Al-Mustansiriya/ Baghdad

voluminous amount of GIS allows civil engineers to manage and share data and turn it into easily understood reports and visualizations that can be analyzed and communicated to others. This data can be related to both a project and its broader geographic context. GIS technology provides a central location to conduct spatial analysis, overlay data, and integrate other solutions and systems. Built on a data base rather than individual project files, GIS enables civil engineers to easily manage, reuse, share, and analyze data, saving time and resources.

A GIS is an organized collection of computer hardware, software, geographic data, and personnel designed to effectively capture, store, retrieve, update, manipulate, analyze, and display all forms of geographically referenced information. as show in figure (1).

GIS is playing an increasingly important role in civil engineering companies', supporting all phases of the infrastructure life cycle .GIS software is interoperable, supporting the many data formats used in the infrastructure life cycle and allowing civil engineers to provide data to various agencies in the required format while maintaining the data's core integrity.

GIS technology provides a central location to conduct spatial analysis, overlay data, and integrate other solutions and systems. Built on a database rather than individual project files.

Views of the GIS

A GIS can be viewed in three ways:

1) The Database View: A GIS is a unique kind of database of the world-a geographic database (geo database). It is an "Information System for Geography." Fundamentally, a GIS is based on a structured database that describes the world in geographic terms [1]. As show in figure (2).

2) The Map View: A GIS is a set of intelligent maps and other views that show features and feature relationships on the earth's surface. Maps of the underlying geographic information can be constructed and used as "windows into the database" to support queries, analysis, and editing of the information .as show in figure (3).

3) The Model View: A GIS is a set of information transformation tools that derive new geographic datasets from existing datasets. These geo-processing functions take information from existing datasets, apply analytic functions, and write results into new derived datasets .show in figure (4).

GIS using in all Phases of civil engineering projects.

GIS software provides civil engineers with the framework for maintaining and deploying critical data and applications across every aspect of the infrastructure project life cycle including planning and design, data collection and management, spatial analysis,construction, and operations management and maintenance. The provides the tools to assemble intelligent GIS applications and improve a project process by giving engineers, construction contractors, surveyors, and analysts a single data source from which to work. Centrally hosting applications and data makes it easy to manage, organize, and integrate geographic data, including CAD data, from existing databases to visualize, analyze, and make decisions. As shown in figure (5).

1- Planning It contains high-level planning functions for site location including environmental impact economic analysis, alternative sitting analysis, routing utilities, data overlay, modeling, and benefit/cost alternatives analysis.

2- Data Collection

It has specific functions to collect precise site data used for redesign analysis; design; and calculations including field survey, topography, soils, subsurface geology, traffic, Photogrammetric, environmental areas, wetlands, hydrology, and other specific design data.

3- Environmental Analysis

It provides analysis to support design including hydrology analysis, volume calculations, soil load analysis, traffic capacity, environmental impact, slope stability, materials consumption, erosion control, and air emissions. During environmental analysis, view project maps, site photos, CAD files, and survey measurements. Analysis of the environment with a GIS allows you to view patterns, trends, and relationships that were not clearly evident without the visualization of data.

4- Design

It allows creation of new infrastructure data for new civil works including grading, contouring, specifications, cross sections, design calculations, mass haul plans, environmental mitigation plans, and equipment staging. This includes integration with traditional design tools such as CAD and data -bases for new design capabilities.

5- Construction

It provides the mechanics and management for building new infrastructure including takeoffs; machine control; earth movement; intermediate construction, volume and material, and payment calculations; materials tracking; logistics; schedules; and traffic management.

6- Data Collection as-Built Surveying

GIS provides the tools to collect precise site data and document existing conditions. With as-built surveying infrastructure data, operators use defined, operational, industry-standard data models. As-built surveying with GIS technology permits the surveyor to deliver data into operational GIS, eliminating costly data conversion and reducing errors

7- Operations/Maintenance

It models utility and infrastructure networks and integrates other related types of data such as raster images and CAD drawings. Spatial selection and display tools allow you to visualize scheduled work, ongoing activities, recurring maintenance problems, and historical information. The topological characteristics of a GIS database can support network tracing and can be used to analyze specific properties or services that may be impacted by such events as stoppages, main breaks, and drainage defects.

Data Integration and Management

You can use GIS to combine and interpret data from many different formats. GIS allows you to integrate satellite images, CAD drawings, and parcel maps to create a visual overview of a project and turn it into easily understood reports. It accepts CAD data without conversion and includes it as a layer in database as shown in figure (6).

A GIS database gives you the ability to handle rich data types and apply sophisticated rules and relationships. In addition to managing large volumes of geographic data, it also implements sophisticated business logic that, for example, builds relationships between data types such as topologies and geometric networks, validates data, and controls access. Data management tools scale to meet your needs, from the individual to workgroups and large, multi-user enterprises. As shown in figure (7).

Infrastructure Management Project

Visualizing assets and the surrounding environment when you build, upgrade, and repair infrastructure helps you decide how to prioritize your work, convince others of its importance, and make good decisions about how to move forward with your plans. Having an accurate, clear picture of the project helps you better understand needs, reduce problems, and mitigate costs and environmental impacts. These processes are improved when GIS is the core system for data Management and visualization. With all the demands on your time, using tools that streamline your business processes and provide you with the best mapping and visualization makes sense. GIS can help you present information in a straight forward way to partners in your projects, government officials, and the public. With ArcGIS Server technology, you can take maps that you have created with ArcGIS Desktop software and used them with your staff in the field can see how a project is progressing. The figure below from (8) to (10) shows the steps of management to selected road.

Applications of GIS in Civil Engineering

Remote sensing and GIS techniques become potential and indispensable tools for solving many problems of civil engineering. Remote sensing observations provides data on earth's resources in a spatial format, GIS co-relates different kinds of spatial data and their attribute data, so as to use them in various fields of civil engineering. The examples below show the used of GIS in many branches of civil engineering.

1- Surface Modeling (Surveying).

Enhancements that make it possible to utilize very large surface models as show in the Figure (11) below:

2-Hydrology & Hydraulics (Design & Analysis)

• Hydraulic Calculators. So that quickly design and analyze your water system as show in Figure (12).

3- Transportation

Route Selection as show in figure (13).

• Mass Haul Diagrams (Documentation)

Moving Material:

•Wizard Based

• Free Haul vs. Overhaul

•Dump Sites & Borrow Pits as show in figure (14)It will be real time assessment of design viability and minimizing project costs. As show in figure (15).

• Road Design

Alignment / Profile Layout

Quickly utilize existing elements such as survey figures to create alignments that can be used during design processes. as show in figure (16)

• Features Lines to the road

It easy of use and Flexibility to solve more complex design tasks with retaining Relationships while design Changes. As show in figure (17).

Easily convert coordinate or raw data files into functional formats as show in figure (18)

4- Management construction

Layers transferred into Arc GIS from AutoCAD may be merged together according to the activities as defined earlier in schedule generated in Microsoft Excel show in figure (19).

Conclusions

The advantages of GIS in this paper are

1- It is provides the accuracy and saves time in the production of map for the project. And it enables to have special maps with different scales at low cost. And these maps act as document for the project, which produced to it and is, used in the design stage, per- tender and estimated cost. This is what the construction manager needs in his job.

2- The features of GIS enable the engineer to operate the model by incorporating any non uniform data. And GIS is used in performing the analysis of large amount of data and Decision making.

3- The database which built (created) in the GIS is very useful for the project especially In the planning stage because the large amount of information save and easy Manipulate with specially accrue for it.

4- The use of the digital map which is produced in GIS for the project saves the time and up-date the information at any time if there is any change in it.

5- The data which is digitally treated and saved as a digital reference for the project can be used as reference for another project.

6- There is always a trend to verify the time and the effort in any civil engineering project. From this fact suggested advice to the civil engineering department to widen the Information about the remote sensing techniques and GIS.

7- It is important to start teaching the GIS techniques in department of civil engineering because these techniques are very useful for the information which any civil engineering project needs such as, urban planning, project site selection, soil studies, Hydrology and environmental studies.

References

[1] Barry F. Kavanagh Surveying Principles and Applications. Eighth Edition. Pearson Education International. (2009).

[2] Brian Culpepper"Planning Support Tools for Northwest Arkansas Communities" National Consortium for Rural GeoSpatial Innovations in America October (2003).

[3] Zhongzhen YANG" Optimizing Highway Alignment in Road Net work" Proceedings of the Eastern Asia Society for Transportation Studies, Vol.4, October, (2003).

[4] V. K. Bansal "Potential of GIS to Find Solutions to Space Related Problems in Construction Industry" World Academy of Science,

Engineering and Technology 32, (2007).

[5] Sandeepan Saha "Application of Remote Sensing and GIS in Civil Engineering" e-mail-sandeepan.saha.august@ gmail.com

[6] Mohd Hasmadi, I. and J.C. Taylor "Sensitivity Analysis of an Optimal Access Road Location in Hilly Forest Area: A GIS Approach" American Journal of Applied Sciences 5 (12): 1686-1692, (2008)

[7] Mohd Hasmadi Ismail "Planning of Access Road Using Satellite Technology And Best Path Modeling "Modern Applied Science Vol. 3, No. 3 (2009).

[8] Richard Hall and Ronaldo Luna "Introduction of GIS into civil engineering Curricula " American Society for Engineering Education, (2007).

Figure (1) GIS Definition

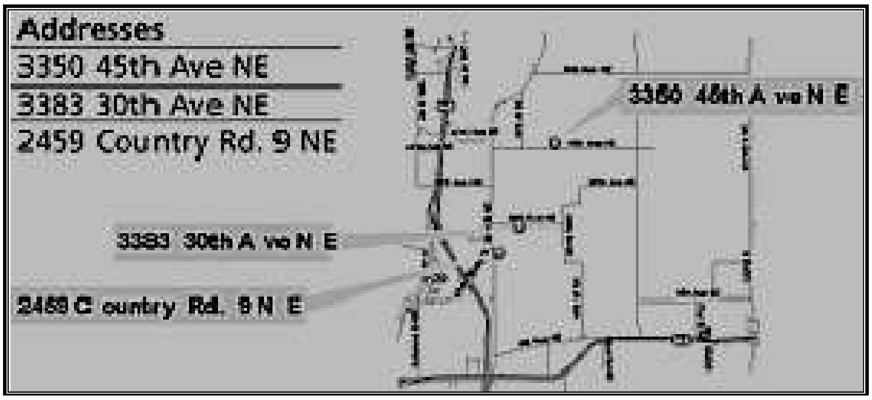


Figure (2) Schematic representation of a GIS .

Figure (3) Schematic representation of a Map [•]

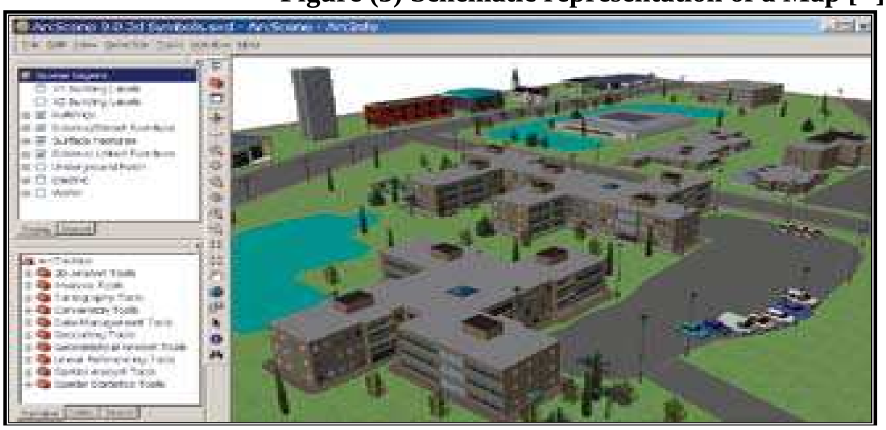


Figure (4) Schematic representation of a Model [5•]

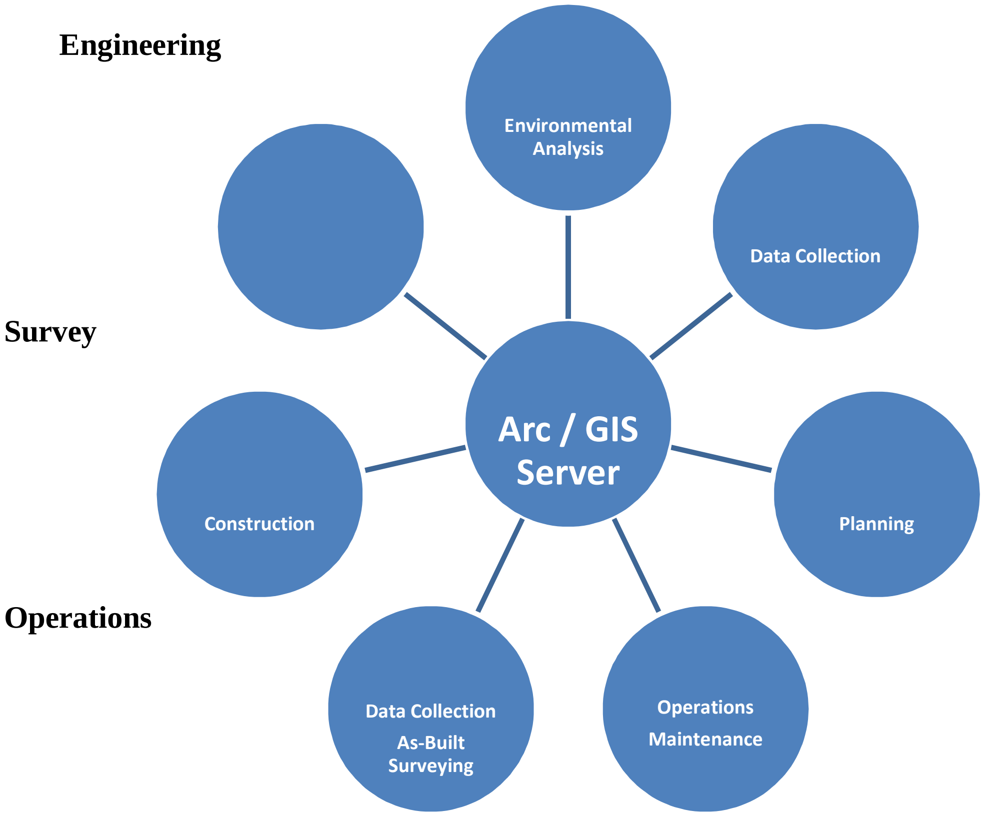


Figure (5) GIS in Phases of civil engineering projects

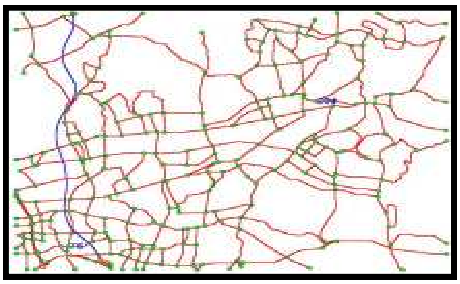


Figure (6) Layer of Road Network in GIS [3]

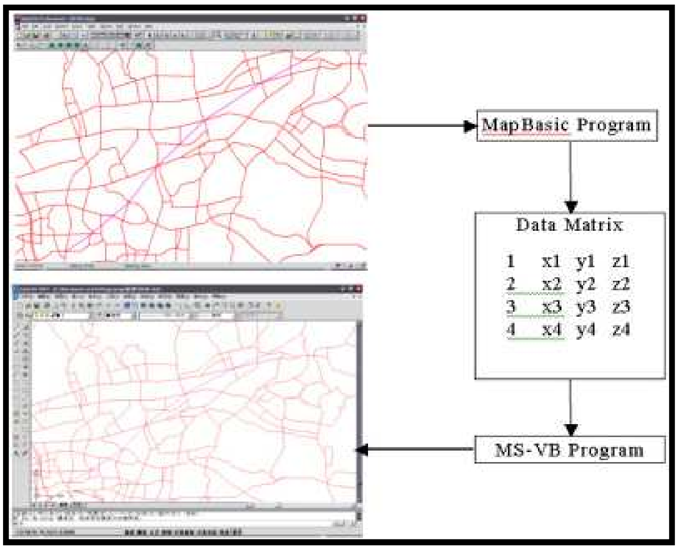


Figure (7) Structure of Data Transfer from MapInfo to AutoCAD [3]

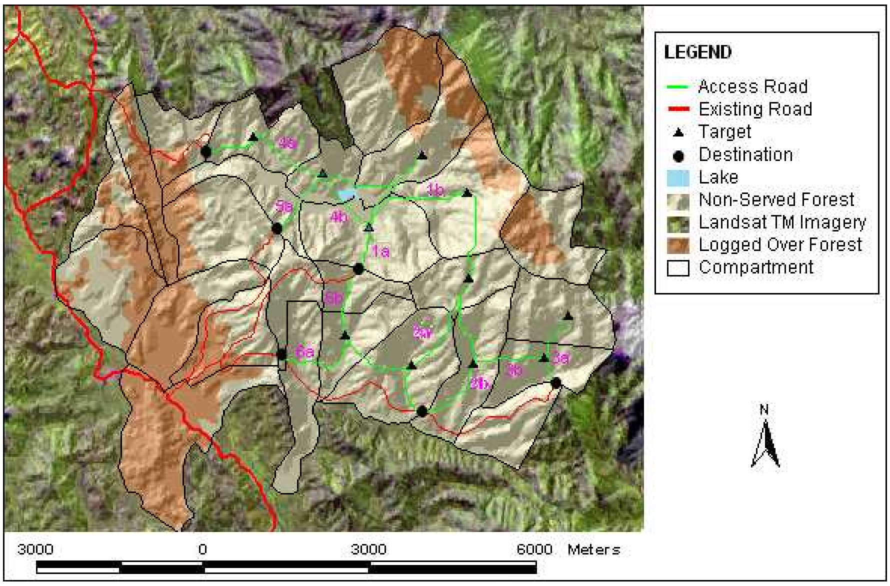
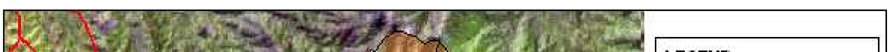


Figure (8) Proposed road location in demonstrated area. [7]



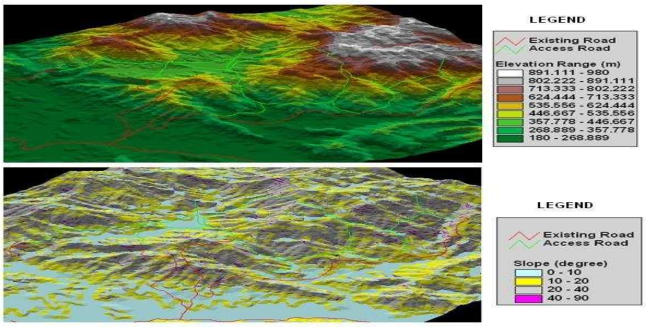


Figure (9) Access road from 3D views of elevation and slope range. [7]

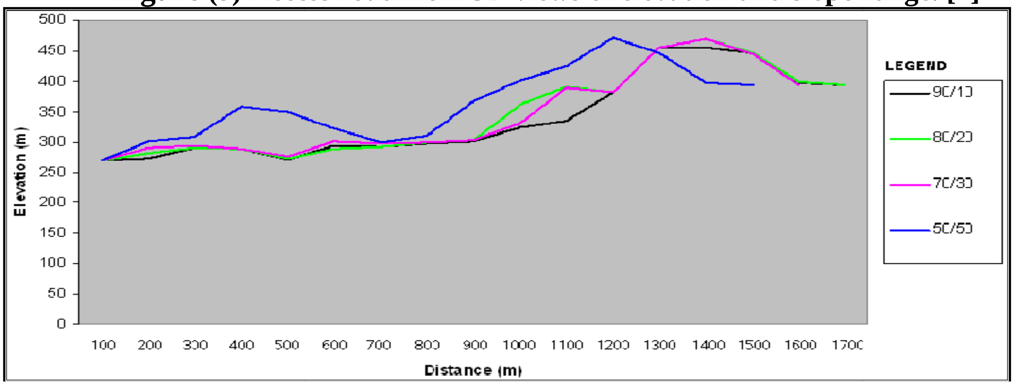


Figure (10) Elevation and slope profile graph for path. [7]

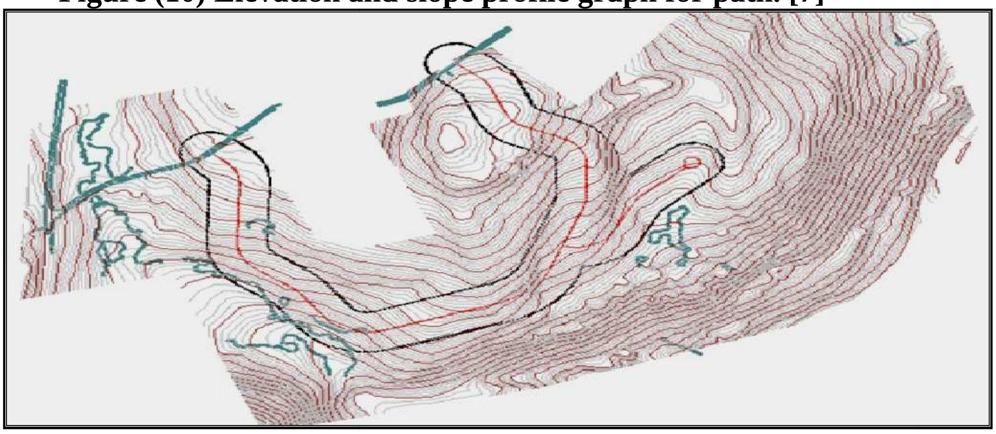
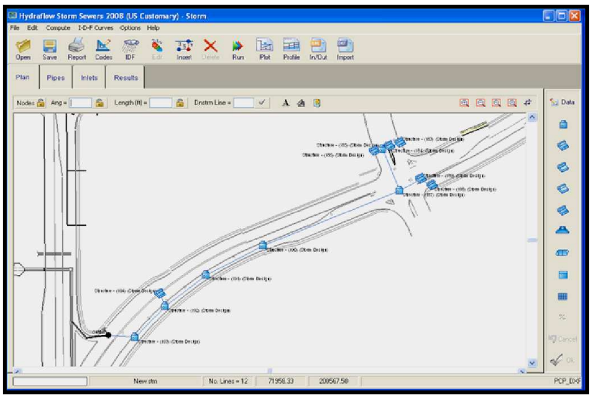


Figure (11) Utilize very large surface models



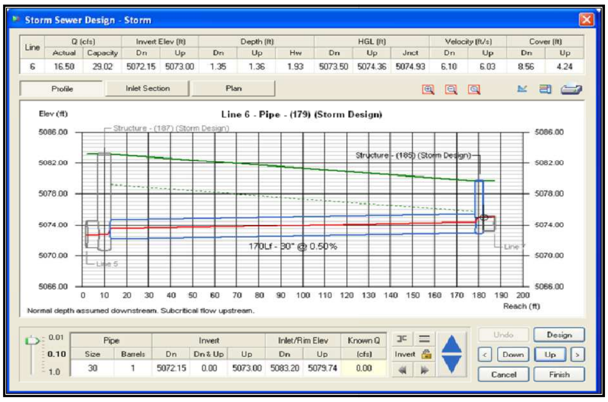


Figure (12) quickly design and analyze your water system and be used easily

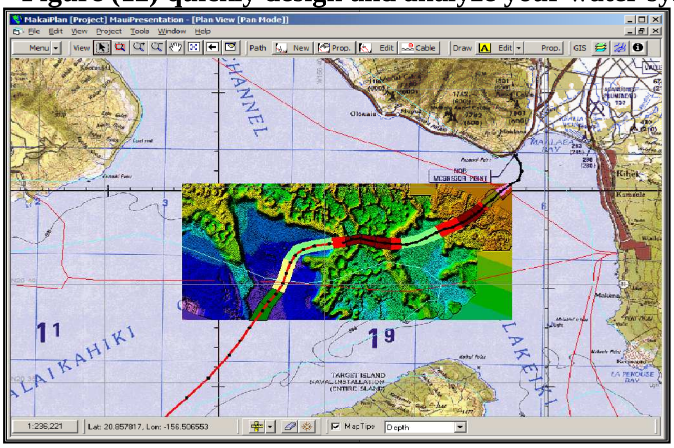


Figure (13) Pictures that is referenced into the GIS database, enhance the quality of the Information available on any given site

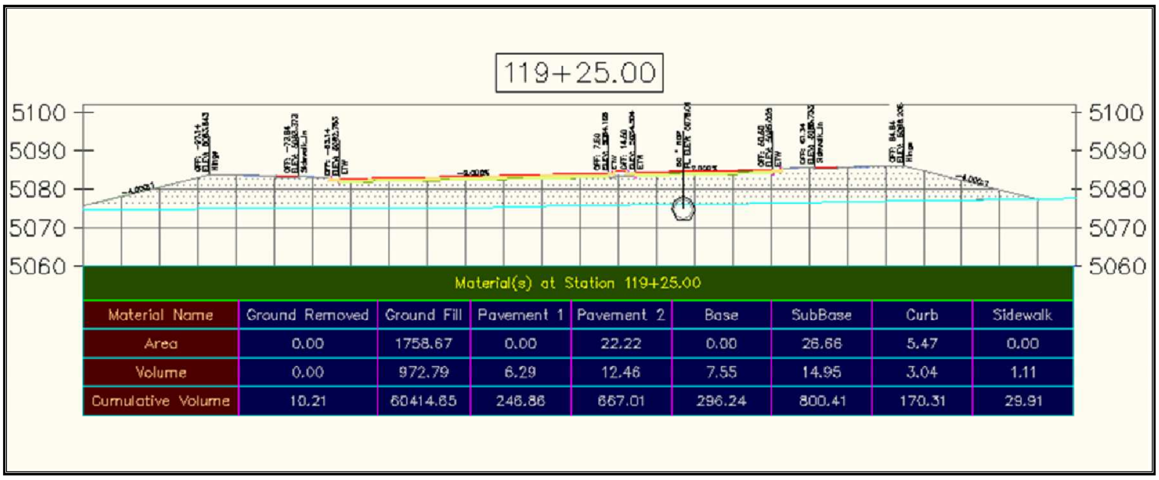


Figure (14) Tools to create and modify so that you can easily create cross section

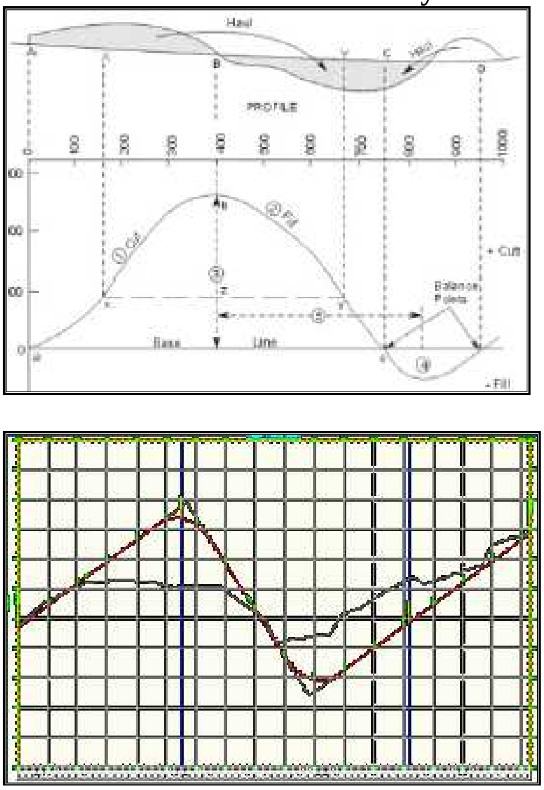


Figure (15) Mass Haul Diagrams.

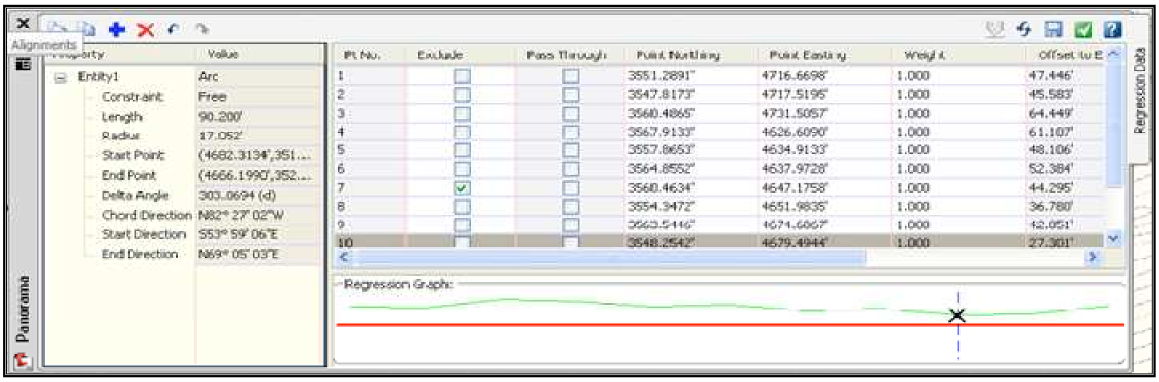


Figure (16) The Alignment of the road

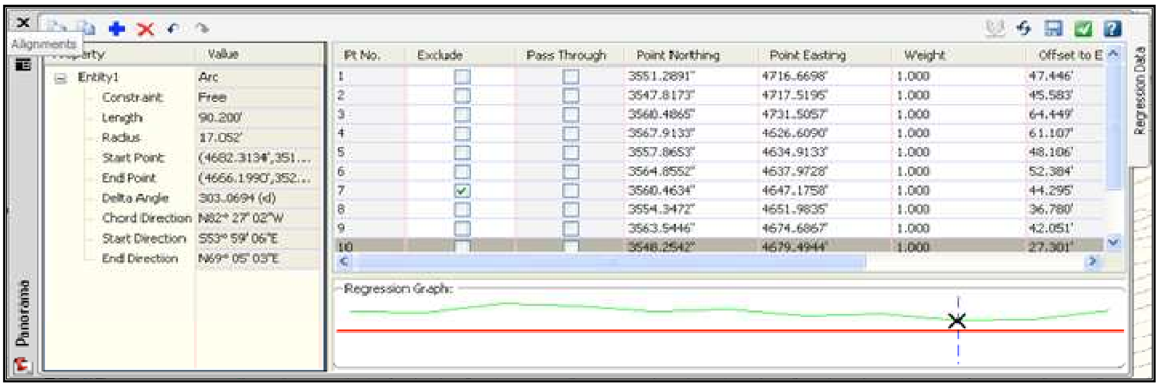


Figure (17) Feature line naming and management.

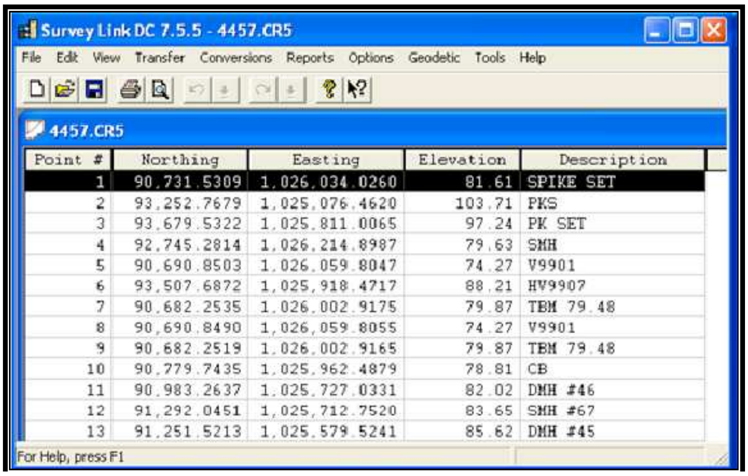
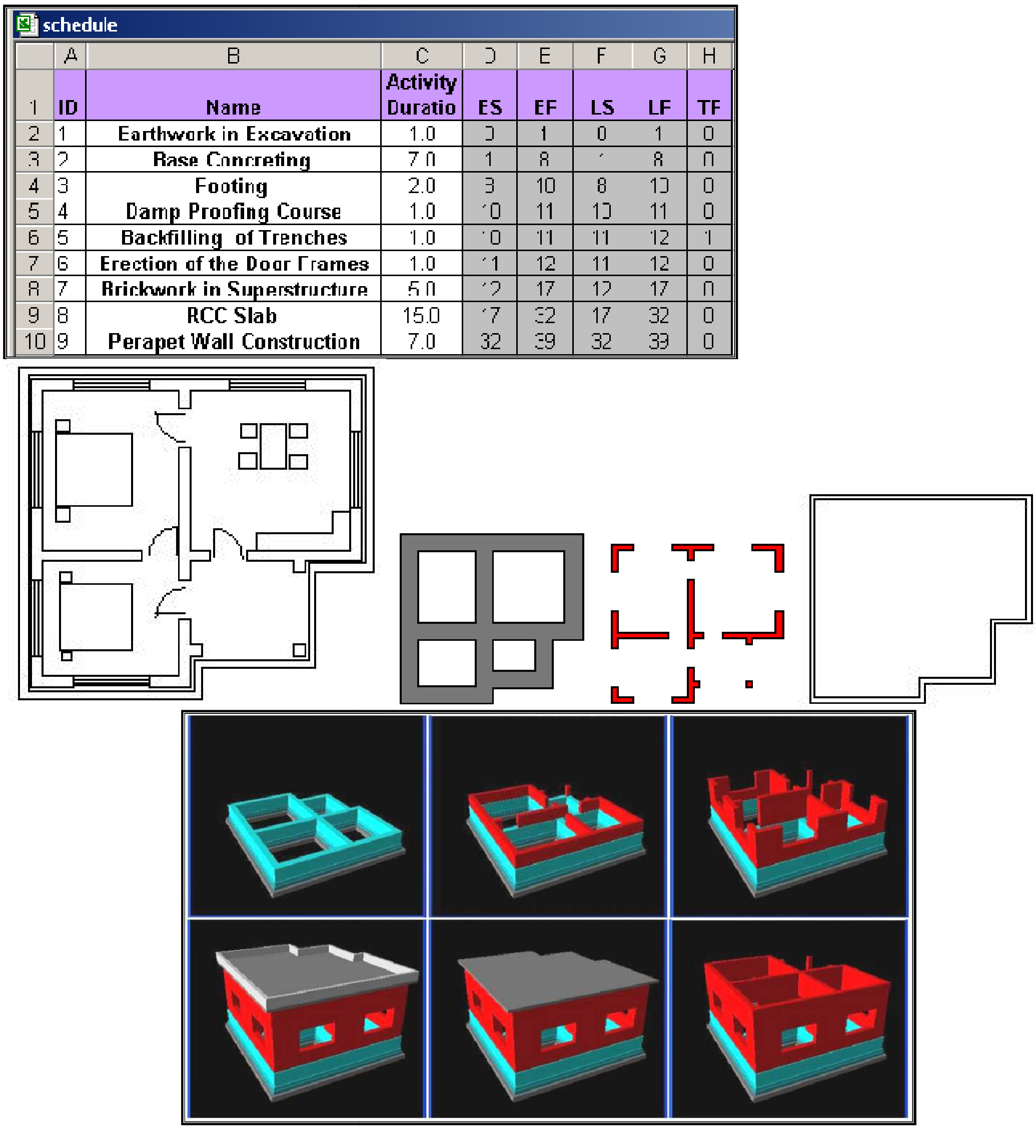


Figure (18) Coordinates and elevation data.


schedule

	A	B	C	D	E	F	G	H
1	ID	Name	Activity Duratio	ES	EF	LS	LF	TF
2	1	Earthwork in Excavation	1.0	0	1	0	1	0
3	2	Base Concreting	7.0	1	8	[illegible]	8	0
4	3	Footing	2.0	3	10	8	10	0
5	4	Damp Proofing Course	1.0	10	11	10	11	0
6	5	Backfilling of Trenches	1.0	10	11	11	12	1
7	6	Erection of the Door Frames	1.0	11	12	11	12	0
8	7	Brickwork in Superstructure	5.0	12	17	12	17	0
9	8	RCC Slab	15.0	17	32	17	32	0
10	9	Perapet Wall Construction	7.0	32	39	32	39	0

Figure (19) Linking the schedule with spatial aspects of the construction activities [4].