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Research Paper

APPLICATIONS OF GIS IN INFRASTRUCTURE PROJECT MANAGEMENT

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Developing countries face unique challenges with the design, construction and operations of new infrastructure. Nations with mature infrastructure have followed traditional technology models for planning, design, construction and operation of facilities. With GIS technology, the development of new infrastructure will follow new technology models eliminating data redundancy, miscommunication, and costly conversion when moving through the planning, design, construction, and operation of infrastructure data. Specific site data requirements for the design and construction of infrastructure are developed for quality engineering design and to minimize and accurately predict construction costs. GIS provides the central data system for the process of developing and constructing infrastructure gives the engineers a common means to communicate geospatial data, maintain current data, and allow iterative design/data collection procedures without exchanging data files of differing format, version, and content. Due to superior spatial data handling capabilities, Geographic Information System (GIS) technology is increasingly being considered for implementation in many infrastructure projects.

Keywords: GIS, Planning, Applications, Geospatial data, Infrastructure projects

INTRODUCTION

The GIS has the potential to merge a person's process and field knowledge with a powerful computer system that documents activity and builds a base for further streamlining. It can remove some of the tedious tasks of day-to-day operations, thereby easing the burden on the worker, resulting in the potential for productivity increases. At the same time, new data documentation requirements are added that form the foundation for future GIS analyses. Wiley suggests that a GIS should be approached as an evolutionary process, one that yields GIS/information system tools and capabilities in the interim and handle users immediate information needs as well as allow for gradual organizational and workflow changes as the system and applications evolve (Wiley, 1997). People involved in the Infrastructure projects believe that saving in

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time and money can be achieved in actual construction rather than applying any structural procedure for project management such as cost estimation, planning, scheduling and control. Further, success or failure depends on the quality and timing of the information available to the engineers from the database.

GIS will allow project managers and different people involved in project with different backgrounds to get the information about the progress of the project and support Decision Making. GIS will provide a common basis of understanding and communication among these people. Many people think of GIS as a presentation tool. A GIS does in fact create high quality maps that communicate considerable amounts of information in an efficient and attention-getting manner. Camp and Brown (1993) suggested the use of database management capabilities of GIS to develop a 3-D view. 3-D visualization allows the project manager to view the construction activities during any stage of the project.

This paper covers the applications of GIS at various stages of Infrastructure projects so that it is possible to maintain the quality throughout the work.

WHY DO WE NEED GIS?

GIS are needed in part because human populations and consumption have reached levels such that many resources, including air and land, are placing substantial limits on human action. Human populations have doubled in the last 50 years. Public organizations have adopted GIS because of legislative mandates, and because GIS aid in governmental functions. For example, emergency service vehicles are regularly dispatched and routed using GIS, Callers to E911 or other emergency response. Dispatchers are automatically identified by telephone number, and their address recalled. The GIS software matches this address to the nearest fire, police, or ambulance station. A map or route description is immediately generated by the software, based on information, on location and the street network, and sent to the appropriate station with a dispatch alarm.

Many businesses have adopted GIS because they provide increased efficiency in the delivery of goods and services. Retail businesses locate stores based on a number of spatially-related factors. Where are the potential customers? What is the spatial distribution of competing businesses? Where are potential new store locations? What is traffic flow near current stores, and how easy is it to park near and access these stores? Spatial analyses are used every day to answer these questions. GIS are also used in hundreds of other business applications, such as to route delivery vehicles, guide advertising, design buildings, plan construction, and sell real estate. GIS provide spatial solutions to many fields of civil engineering such as transportation, water resources, facilities management, urban planning, construction and E-business. GIS is an effective tool to visualize the topographical conditions of construction site. The modelling of construction site facilitates in construction controlling and planning process.

WHY GIS IN PROJECT MANAGEMENT?

The Construction Industry has a huge number

of tasks involved and cost involved in these Projects is also very large. The Project Managers have a hard time monitoring the projects between site and office. They have to come on site to know the progress of work and decide the sequence of work. They are generally confused on what to do next or what would be the changes faced by them in future. So the cost involved is large and it varies with respect to the completion of the project, i.e., time. The traditional approach for scheduling and progress control techniques such as bar charts and the critical path method are still being used by the project managers for planning which a serious disadvantage for the decision is making purpose as the spatial aspects fail to provide the required information. There is pressure on the project managers to shorten the delivery times and thus the current scheduling and progress reporting practices are in need of substantial improvements in quality and efficiency. Integration of Geographical Information System (GIS) and project management with visualization was recognized as one of the most important tools for achieving this goal. It should be seen that integration of GIS and Project management might assist a planner in a better perception of a project as well as in the integration of other parties' activities in the planning process. Furthermore, in large scale projects, a visual representation of the schedule can be extended to monitoring not only the construction process itself, but also all the auxiliary activities, including onsite plant and equipment. In addition, the practical and educational benefits of being able to visualize construction at a fine level of detail are significant. The application of geographic information system in project management will be new in the Indian Construction industry. GIS will allow construction managers and different people involved in project with different backgrounds to get the information about the progress of the project and support Decision Making. GIS will provide a common basis of understanding and communication among these people. Many people think of GIS as a presentation tool. A GIS does in fact create high quality maps that communicate considerable amounts of information in an efficient and attention-getting manner. 3-D visualization allows the construction manager to view the construction activities during any stage of the construction process. GIS can be integrated with project Management for construction progress visualization and an integrated information system.

ROLE OF GIS IN PROJECT MANAGEMENT

GIS is a computer system for capturing, storing, quarrying, analyzing, and displaying Geographic data. GIS is a special class of information system, which can be divided into four Components involving a computer system, GIS software, human expert, and the data. GIS activity can be grouped into spatial data input, attribute data management, data display, Data exploration, data analysis, and GIS modelling.

GIS can handle both spatial and Attribute data, spatial data relate to the geometry of the features, while attribute data describes the characteristics of the different features and stored in the tabular form. Each Row of the table represents a feature while column represents the characteristic of features. The intersection of a column and a row show the

value of particular characteristics of a feature.

In the georelational data model, split data system is used to store spatial and Attribute data in separate files and linked together by the feature Identification Descriptor (ID). These two sets of data files are synchronized so that both can be quarried, analyzed, and displayed. GIS role have proliferated in the construction industry in recent years. This fact is illustrated by the growing number of articles finding their way into civil engineering and Construction journals and conference proceedings, in addition to the handful of special Publications devoted to GIS (Oloufa *et al.,* 1994).

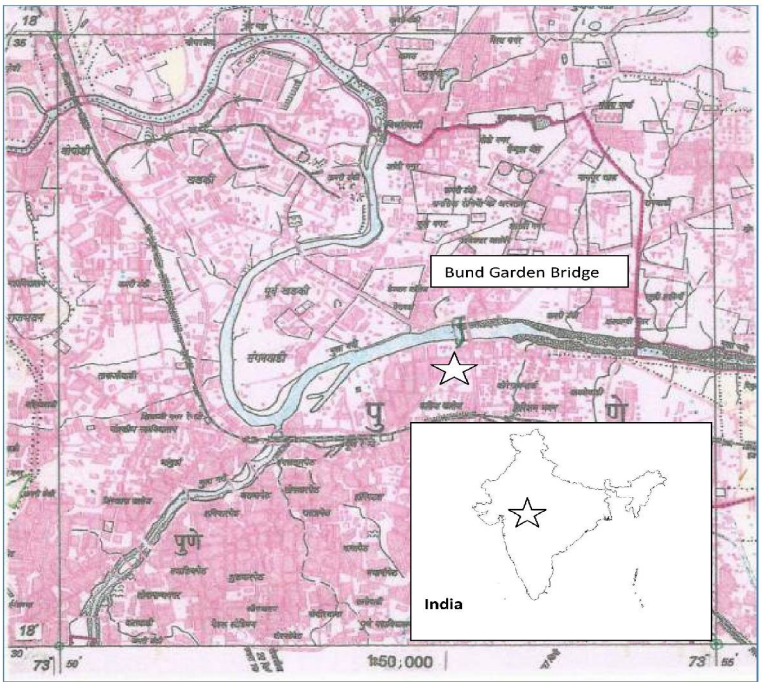
GIS can be used for:

- Progress monitoring system in construction
- 3-D data analysis
- Comparison of data
- Construction scheduling and progress control with 3-D visualization
- Government Regulations

SITE LOCATION

The new four-lane bridge on the Mula-Mutha River confluence at Yerawada, Pune, India, has been named after Babasaheb Ambedkar and will be an alternative to the Fitzgerald bridge, also known as Bund Garden bridge (Figure 1). The old bridge is a heritage structure, constructed in 1867 in British era. The first spandrel arch bridge in the city, connecting Bund Garden to Chima garden. The need for the new bridge at this location arises from the fact that the existing two lane masonry arch bridge has over lived its design life span and can become redundant for public use in the near future.

Figure 1: The Bund Garden Bridge site near Yerawada, Pune, India



Site Data and Equipment

Toposheet collected from Survey of India from which new location of Bund garden bridge on Mula Mutha River marked manually from existing old bridge. This has been shown in map of Pune city 47/F/14 (Figure 1). AutoCAD drawing of New Bridge (Figure 2), approximate estimate, Project schedule data, Manpower status during the project, Cash flow statement, etc., and GRAM ++ GIS Software version 2.0 used in this project.

Registration of Map and AutoCAD Drawing in GIS Software

Geospatial location of new bund garden bridge on the map of 1:50,000 scales registered in the Map Edit module of GRAM++ GIS software (Figure 3). After registration of the map, two segment layers have been drawn one is Mula-Mutha River and another is new bridge. This file saves as a vector file in software so that spatial location of the object, found out easily (Figure 4). This digitize layer of bridge over

Figure 2: AutoCAD Drawing

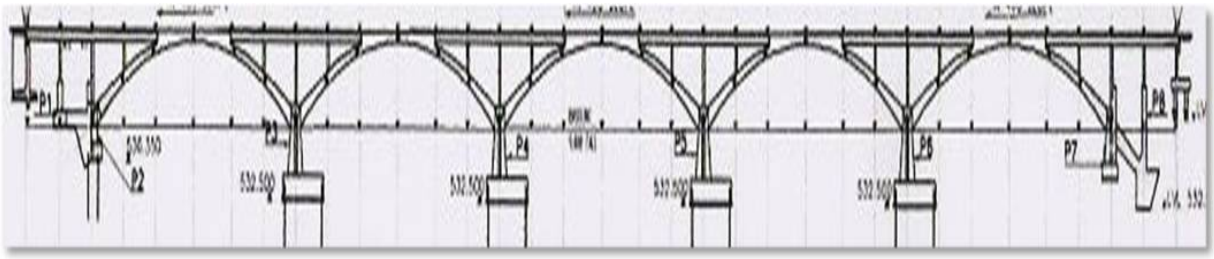


Figure 3: Registration of Map

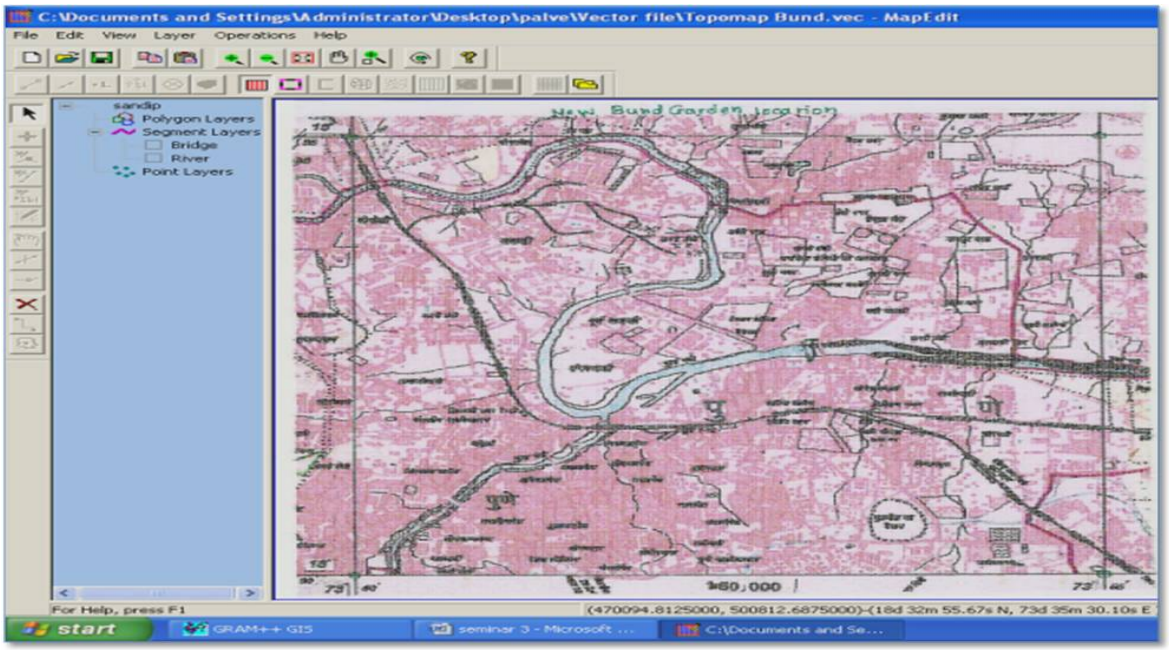
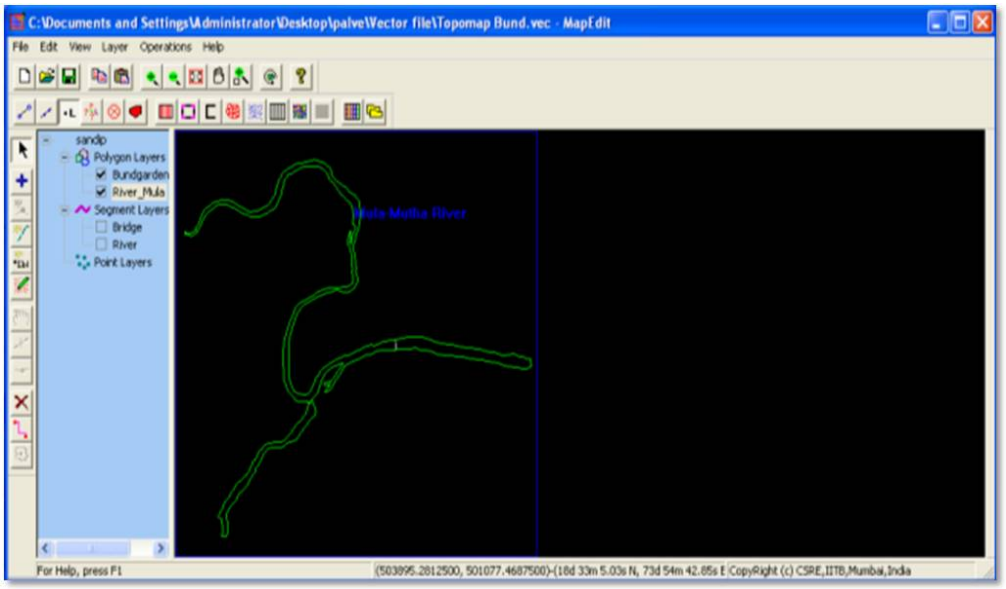


Figure 4: Digitization of Bridge and River



the river helps in finding out the location of object and same points were transferred in the AutoCAD drawing, so as to marked accurately as like as ground coordinated points (Figure 5).

Digitizing AutoCAD Drawing in GIS Format

The polygon, segment and point layers are created for activities. All activities in the project merged together into one activity so that; the

Figure 5: Registration of AutoCAD Drawing

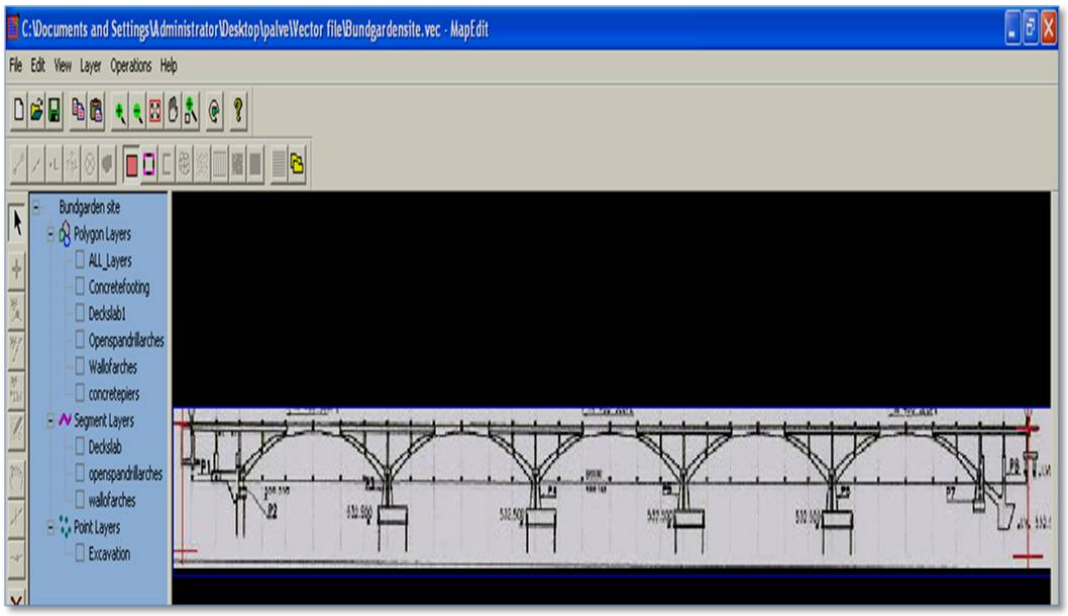
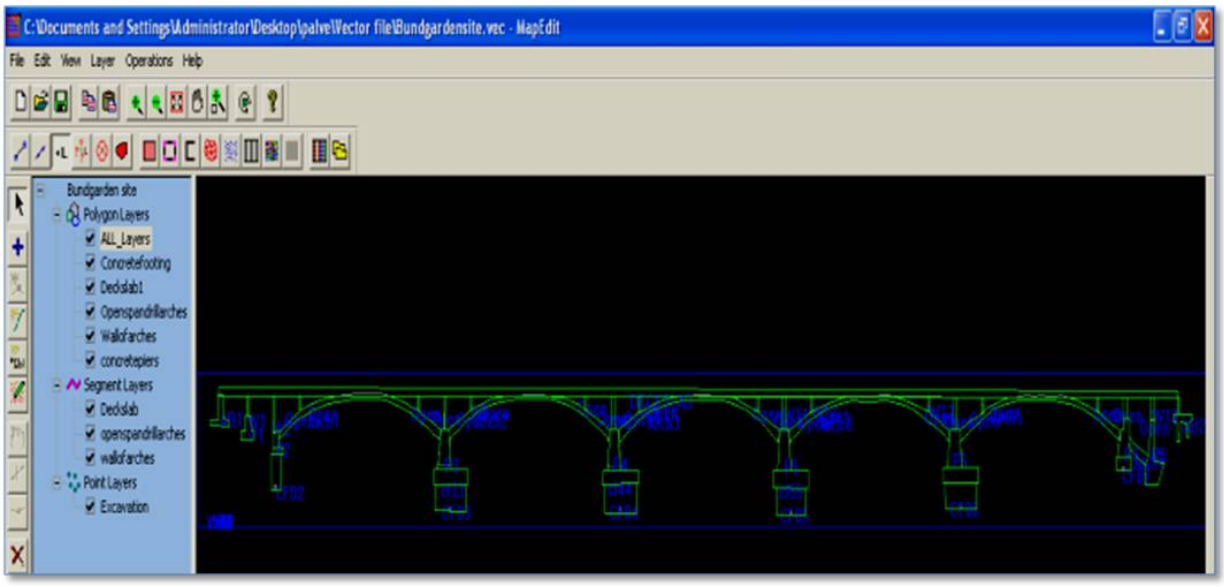


Figure 6: Digitization of AutoCAD Ddrawing

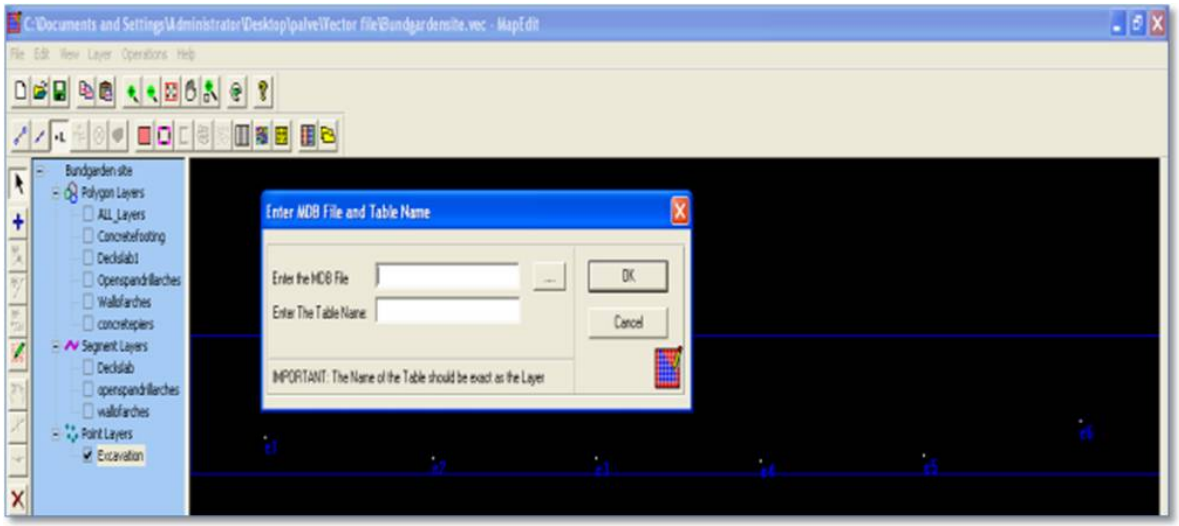


activities which belong to each other but were located at different positions are joined together as a one Feature Class (Figure 6). These files save as a vector file in the module of software which helps in creating a database for different activities of project in sequence.

Database Generation for Feature Class, Activities

The attributes needed for each layer were created in a database (Figure 7). Once the database generated it gives the information about total percentage of completed work,

Figure 7: Database created in mdb. File

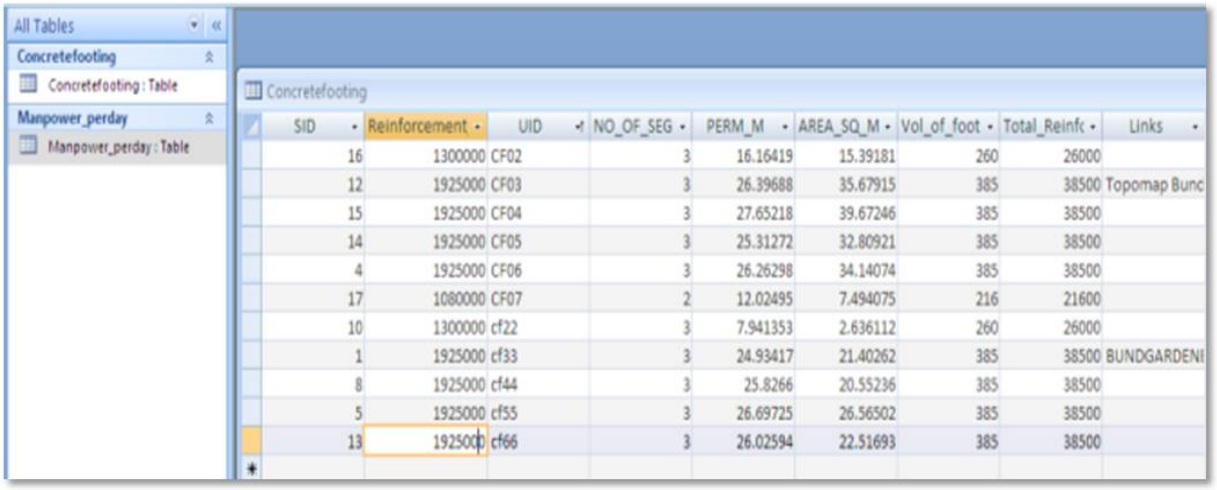


total manpower required during the activities and generate the cash flow required for project. This centrally located database enables the engineer for streamlining the operation of project in real time. The attribute for all activities from excavation to end of the deck slab generated in system. Figure 8 shows the attribute table of concrete footing.

PROGRESS OF WORK

The progress of work had shown in graphical format. The amount of work done on the various activities could be seen in 3D view. The project was updated as progress information became available. The various formats of reports can be generated as per the user's requirement. Query run on concrete footing when selecting the volume of footing equal to be 216 m³ then it appears to be red in color (Figure 9) and 3 D view of concrete footing generated in vector visualize, module of GRAM++ GIS software (Figure 10).

Figure 8: Attribute Table for Concretefooting



SID	Reinforcement	UID	NO_OF_SEG	PERM_M	AREA_SQ_M	Vol_of_foot	Total_Reinfc	Links
16	1300000	CF02	3	16.16419	15.39181	260	26000	
12	1925000	CF03	3	26.39688	35.67915	385	38500	Topomap Bunc
15	1925000	CF04	3	27.65218	39.67246	385	38500	
14	1925000	CF05	3	25.31272	32.80921	385	38500	
4	1925000	CF06	3	26.26298	34.14074	385	38500	
17	1080000	CF07	2	12.02495	7.494075	216	21600	
10	1300000	cf22	3	7.941353	2.636112	260	26000	
1	1925000	cf33	3	24.93417	21.40262	385	38500	BUNDGARDENI
8	1925000	cf44	3	25.8266	20.55236	385	38500	
5	1925000	cf55	3	26.69725	26.56502	385	38500	
13	1925000	cf66	3	26.02594	22.51693	385	38500	

Figure 9: Query on Selective Region in Red Colour

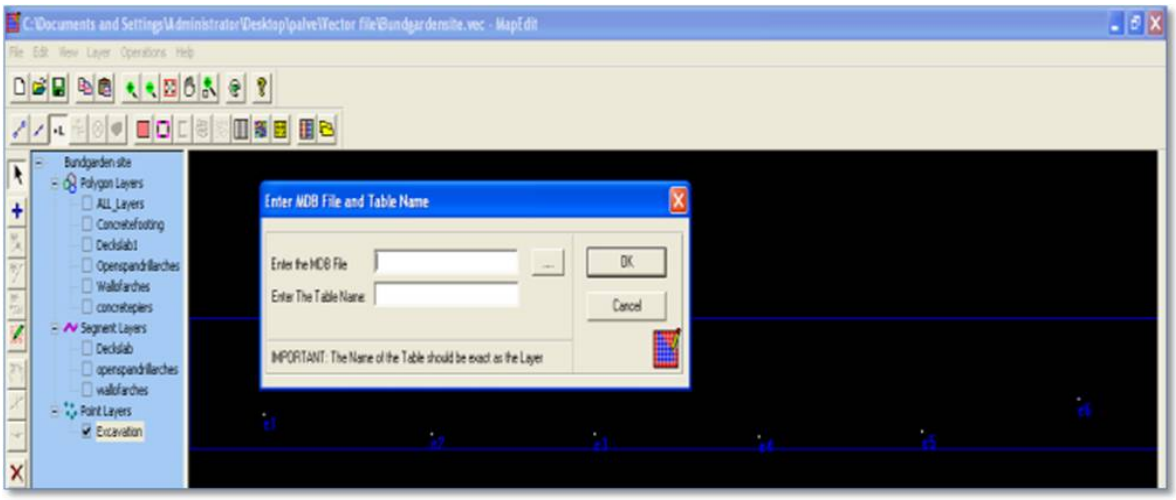
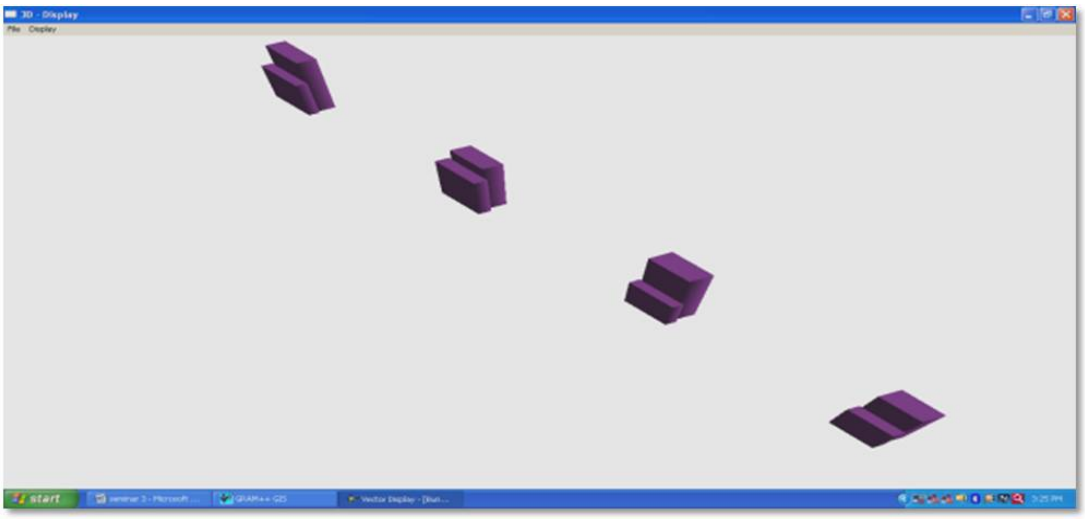


Figure 10: 3D View of Concrete Footing



Subsequently the same procedure applied for other component of the project. All components of the project and its database finally merged together into the one common layer (ALL_ Layers) (Figure 11).

Project schedule (Figure 12) is a vital ingredient in successful project management. Numerous individuals and parties are involved in project, and they have to understand their assignments. Proper scheduling is an important procedure for project, as it supports the efforts to control cost and time. Good

Figure 11: ALL Layers Activities

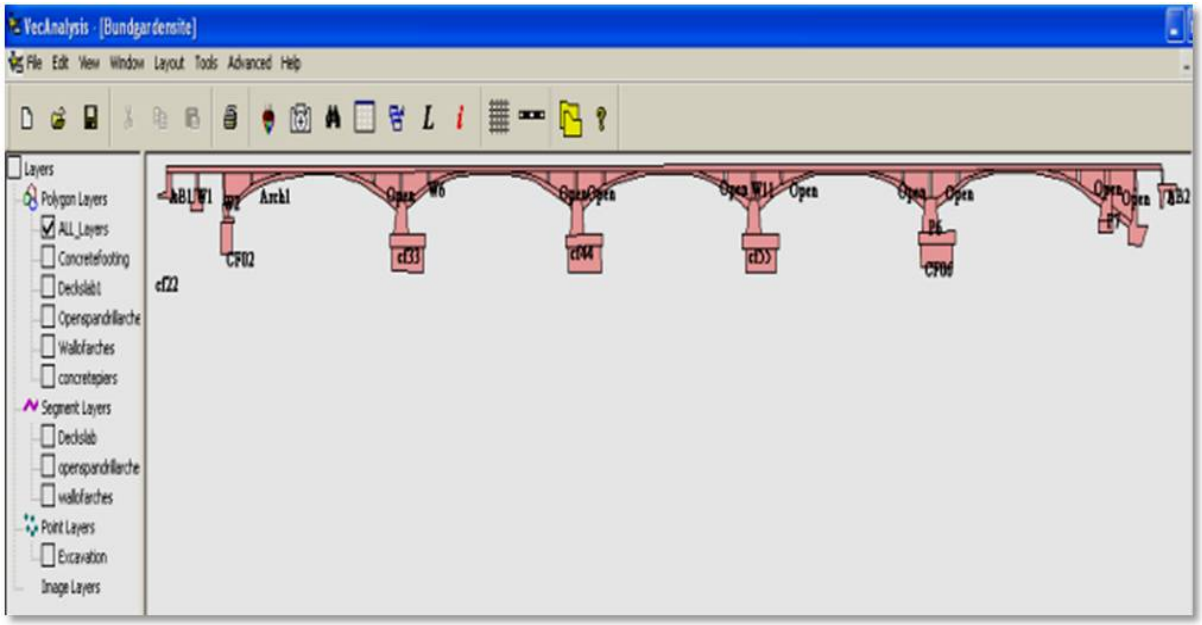
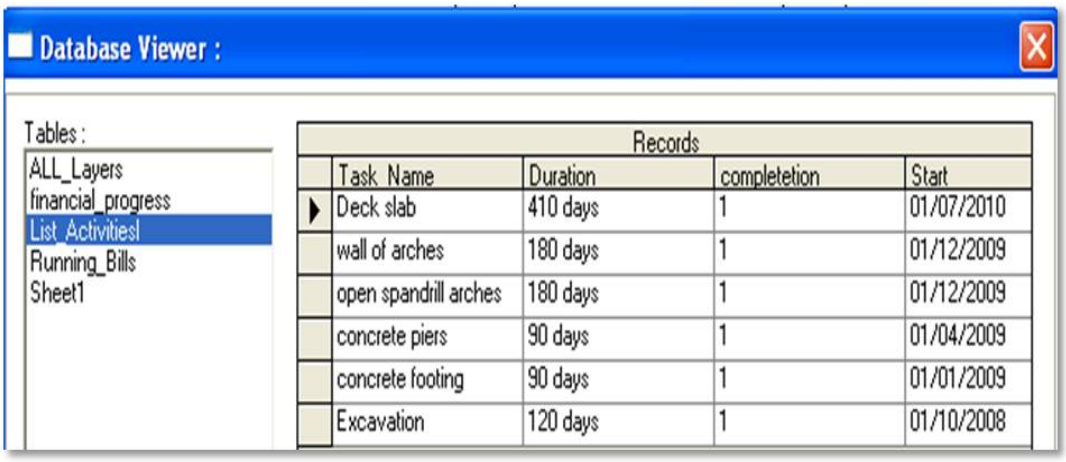


Figure 12: Database for Project Schedule



scheduling can eliminate problems due to bottlenecks; facilitate the timely completion of a project as soon as possible.

CASH FLOW STATEMENT

Cash flow statement is useful to plan financial operations in an efficient manner. Planned cash flow which is at beginning of the project and actual cash flow during the project helps to provide vital information about organization's cash inflows and outflows (Figure 13). The graph of cash inflows and outflows (Figure 14) shows that, how an organization's financial position has changed during the reporting period. It helps to control the cost of project over the period of time.

DESIGN OF 3D MODELLING

The completed work and its 3D view (Figure 15) created in vector visualize module of GRAM++ GIS software. Project manager should be determining the stage in the design development process when a specific scope of work should be modelled in 3D.This technology provide significant benefits in developing coordinated and constructible designs and construction sequences which helps in knowing the exact status of the project. The potential of these tools significantly improve design coordination and construction execution.

BENEFITS OF THE SYSTEM

This system will benefit project managers, site engineers and clients in the following Manner.

Project Manager

Project manager evaluate the project to ensure that it meets the desired standards. During project execution, project manager continually review performance. Depending on priorities, he knows how much progress has been made, how much money has been spent, and what results have been achieved. With well defined and integrating system of GIS software not only Progress of the work, costs, and quality, but we evaluate project performance and the company's business objectives. With the help of this integrating system, the Project manager compares actual work and costs to the project

Figure 13: Database Sheet for Cash Flow Statement

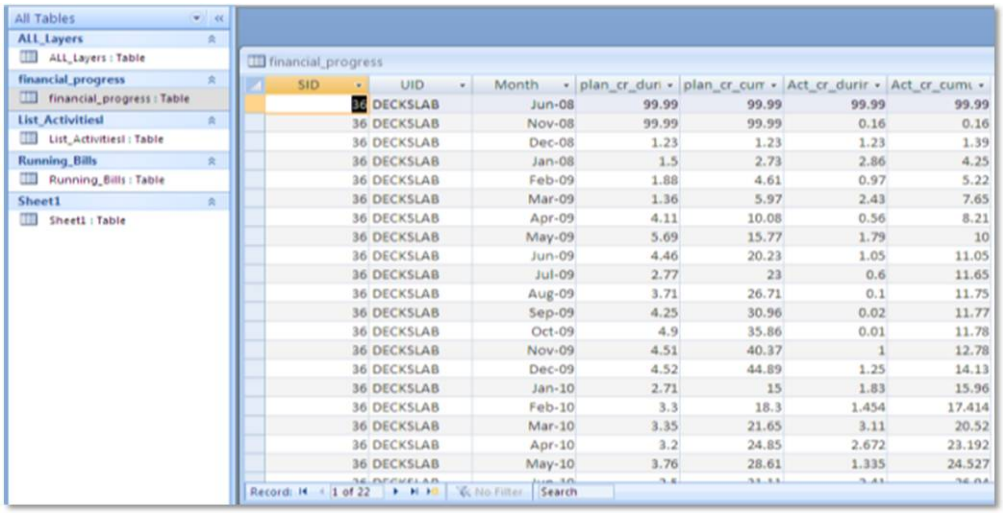
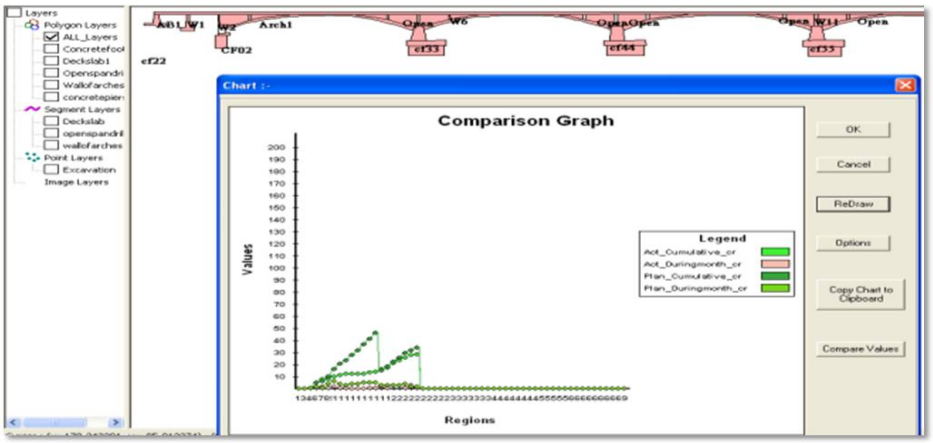


Figure 14: Graph of Cash Inflows And Outflows During The Project



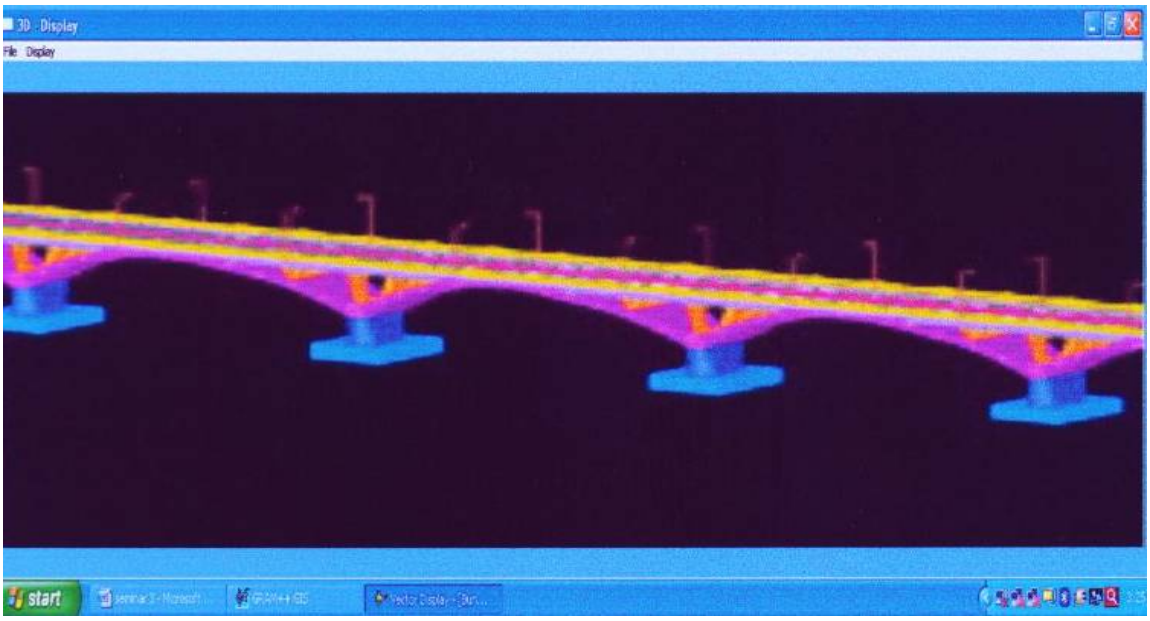
plan to determine whether the project is behind schedule or over budget, the amount of any budget overruns, controlled.

Site Engineer

Site engineer understand the status of work which helps in good decisions in his day-to-day work. Proper Information system track the progress of work and any changes can be made within short period of time, before things get out of hand.

Quantities of materials required and the actual construction work involved in implementing a project carried out by engineer. Monitoring of project's cash flow possible with updating day to day work in database. Software manages the construction processes so that the project is completed on or before the agreed completion date which ultimately saves the time value for money.

Figure 15: 3 D View of Completed Project



Client

3D modelling tools offer pre-defined objects that facilitate the development, routing, and connection of bridge construction in 3D. The potential of these tools significantly improve design coordination and construction execution. This system can be applied to resolve complex design and construction challenges. 3D technologies provide significant benefits in developing coordinated and constructible designs and construction sequences which helps in knowing the exact status of the project. These technologies help in improving the quality in construction projects.

CONCLUSION

Planning and managing the infrastructure projects in the new era of globalization and economic liberalization would be a demanding task calling for new skills and approach. The infrastructure projects of developing countries must be improved as they are of critical importance to national socioeconomic development.

GIS makes a wealth of information, easily available from a spatial interface. It also helps to organize all relevant information, for project tracking. When we initiate new projects, we are accountable for effective and efficient project delivery. Large projects are often complex, which require careful monitoring, coordination, and management. GIS uses location as the cornerstone of data management for organizing project information.

Through the use of 3D modelling in GRAM++ GIS software, clients can experience a more interactive way of seeing data, visualizing change over time and space to identify patterns and trends, and disseminate knowledge to engineers, managers, and field-based personnel.

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