

# APPLICATION OF GIS IN CONSTRUCTION MANAGEMENT

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**Abstract** - Geographic Information System (GIS) has been used in many fields of Science including engineering. GIS is a Computer based tool which is used to solve engineering problems related to spatial data. The potential importance of GIS to construction management in the construction industry has not been realized completely. GIS technologies have the potential to solve space related problems of construction management involving, integration of information, urban planning, project site selection, soil studies, hydrology and environmental studies. It was found that the construction industry in Sri Lanka is reluctant to apply the GIS in the construction projects. Therefore, this study was aimed to analyse the implementation issues of the application of GIS in the field of quantity surveying as a part of construction management in engineering. Interviews were conducted to gather data from the senior quantity surveyors in the fields of construction and project management. The sample was 40 and the selection method was purposive sampling specially based on the direct involvement in the project under the capacity of decision making. The study was done by using only the primary data and the analysis was done by developing a comprehensive content analysis. It was found that there are key issues in the implementation of GIS including the unawareness and the overlapping with other specific techniques. The respondents have proposed the possible ways of implementing GIS to the construction management for enhancing the productivity of the projects specially by doing a proper cost benefit analysis.

**Keywords:** Geographical Information System (GIS), Construction Management, Custom Application, Project Management

## I. INTRODUCTION

Geographic information system (GIS) can be stated as a system designed to store, retrieve, manage, display, and analyse all types of geographic and spatial data. Basically, it is a computer-based tool which used to input, storage, management, retrieval and output of information. The GIS information connects to the attributes of geographical locations. In GIS basically shows what is located at a specific location geographically. GIS has various definitions and meanings in different aspects. GIS is a combination of both hardware and software used in working with the spatial information. GIS can answer for following questions,

- What exists or what is there at a given location?
- Where something does has occurred?
- What has changed of a specific point in some period of time?
- What kinds of spatial patterns do exist?

Most commonly GIS has defined as a specific software package used in handling and dealing with the spatial information. Geographical information can be identified as a the information about a name of a place, a street address, state or province, zip code information and coordinates of longitudes and latitudes. GIS enables, examining and analysing geographical information in different levels of detail or from different aspects. Also, it able in customizing the display of the maps and analyses in order for different purposes for different audiences for presenting. For Government Purposes the requirement of GIS can be vary and almost seventy percent of the information that are used include geographical reference. By using a GIS application it is capable of opening digital maps on computer and create a new spatial information that can be added to a map and also create printed maps

and customised according to the user needs and execute spatial analysis. Geographical data that are used in GIS are raster and vector data. The location of certain features are considered in relation to another feature on land in below applications such as assessing the property records, zoning, tracking the permits, management of natural resources, management of transportation and infrastructure, planning the economic development and the public health and safety (Anbazhagan, 2003). By relating the features the GIS system allows the user to visualize the relationships in between.

GIS can be used in different professions in construction industry. For Architects to design 3D maps and to solve query data about the elements geographically to make the design and to perform an analysis about the design. Mainly most of the Mechanical, Electrical, Plumbing (MEP) designers this GIS tool helps to design the 3D concept of the design and its exact locations. For Engineers the GIS designs and databases will help to enhance the accuracy to locate the exact locations of the geographical locations of the elements (Hemal, 2000). For Quantity Surveyors, to take off quantities, preparation of Bills of Quantities, compare GIS quantities with site quantities GIS is a handy tool. For Surveyors to demarcate land areas and to calculate cut and fill soil volumes of a particular land area the GIS technology is used.

**A. Literature Review**

The Construction Industry comprises of number of complex set of activities that has a huge number of tasks and cost that has involved in construction projects is a huge concern. The role of Quantity Surveyors and project management techniques used heavily effect to the success of project is very much important and sometimes they may confused on what to do next or what is the best step that has to be taken (Kolagotla, 2009). GIS has the ability to integrate miscellaneous data sets, databases and different applications in order to support and enhance the decision making among the professional in project (Chang, 2006). Many believed that the cost and time can be controlled in construction but doesn't realise that through efficient and effective cost estimation, planning, scheduling and control it can be done (Bansal and Pal, 2006). GIS can be used in construction industry for various types' tasks. The estimates prepared without detailed engineering data considered as less accurate. Therefore, GIS provides a database to store, access and manipulate data which can be used for accurate cost estimation (Bansal, 2011). GIS has the ability to recognize points, lines and areas of spatial objects. There

are analytical functions that can perform such as, overlay operations, neighborhood functions, and connectivity functions which are proximity and network operations (Sebt et al., 2008). The application of GIS in construction sector has in Taking off quantities, Real time updating of Construction progress, Transport, Watershed Analysis, Environment Impact Assessment, Remote Sensing, Urban Development, Target Site Selection, Landfill Site Selection, Mineral mapping, Pollution Monitoring, Natural Hazard Assessment, Resource Management.

GIS can replace the manual methods of quantity takeoffs and to assess the materials layout design (Bansal and Pal, 2006). Due to the complexity and large varieties of activities the integration between the Project Management and GIS is a key part of the solution. By this enables the person to visualize the construction progress with the time (Kolagotla, 2009). Recently an automated site layout system was developed for construction materials. It was consisted of a new tool to help the managers to determine the most suitable and economical areas to locate construction materials. Using GIS the geographical location details are linked about the graphical features of the stores and shops. Then based on particular project's estimating quantities and final detailed design the most suitable store is selected. There will be few attributes in concern that will help in deciding the most appropriate supplier and the attributes will be weighted as per the importance (Cheng MY, 2001). As a summary the application in GIS for construction industry and construction management is identified in various aspects. The applications are researched in different professions by realizing the application that can be implemented to increase the efficiency and effectiveness by time saving to achieve the project outcome.

**II. METHODOLOGY AND EXPERIMENTAL DESIGN**

This research is mainly conducted through primary data collected via interviews and this is a mix of Qualitative and Quantitative data. The main objective was to find out the awareness, types of construction GIS can be applicable, ongoing construction projects using GIS, advantages and effective output that can be achieved by using a standard GIS and steps that need to be implemented in order to increase the GIS usage in Sri Lankan construction sector. The interviews were conducted from the professionals in the construction sector whom possess a vast knowledge and experience in the field. A set of questions were asked from them with given appropriate answers and based

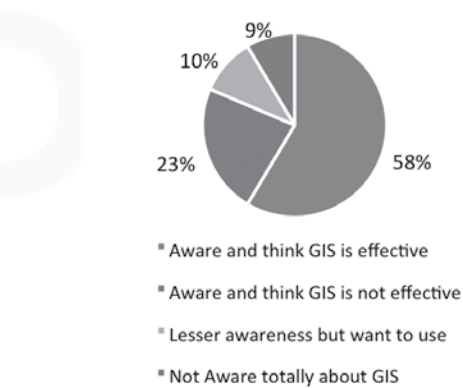
on them the interviews were conducted. The questions were answered with their opinions and experience in the construction projects they have worked and involved in. The interviews were conducted over 30 professionals from chartered Quantity surveyors, Engineers, Architects, Surveyors and Project managers about their role and how their views and opinions about the current usage of GIS technology and how they can be used and steps to be taken to increase the usage.

### III. DATA COLLECTION AND RESULTS

As per the data collected through conducting the interviews from different personnel whom are experienced in field of construction the data was analysed. The interviews were conducted in aid of a questionnaire and answering to those questions and elaborating their perspectives and views on those questions were recorded. The data was collected through 40 different professionals whom have currently involved in construction sector as professionals. As a whole, the GIS usage and implementation in construction sector has a low involvement. Mostly since the surveyors that has more knowledge in GIS uses it for demarcating and locating different kinds of activities. The involvement in mega building projects also has some involvement and for small projects GIS is not used commonly. In pre contract stage GIS can be used for finalise a detailed 3D design including the heights and accurate locations. For Post contract stage GIS can be used to locate the actual location of the building services or any other element to carry out the practical construction without creating a dispute accurately. Mainly for infrastructure projects such as irrigation projects including piping projects and waste water projects, Telecommunication projects and Electrical projects by Ceylon Electricity Board the usage of GIS in order to locate and to identify the elements. Mainly the National Water Supply and Drainage Board (NWSDB) use GIS to identify the locations where the valves, pipes are located from their latitudes and longitudes and path it runs through for maintenance purposes.

The GIS database will be prepared if only the request of the client in most of the construction projects. If the client has a GIS database it will be updated by contractor and handing over is done in modern projects. It contains the manholes, junctions, valves and other elements data feeding to the GIS database. For large scale projects which covers a large area a GIS database is mostly useful. GIS can be used for road constructions. Mainly that is used in

expressway networks to implement structure locations, camera networks and structure health monitoring. Another point that discovered was that the GIS design for infrastructure projects is a very much useful way to visualise the entire premises in a 3D aspect. If the designer is far away from the site location he or she can visualise the location and decide what steps need to be taken and the condition of the site. Mainly in foreign projects without visiting to the practical site the decisions can be made if the GIS design is available. Moreover, the costs for the trial pits in order to decide the exact locating the services laying underground such as water pipes, sewerage lines, electrical cables and telecommunication lines can be easily identified with the accurate location due to the outdated data in surveying department.



**Figure 1. Awareness of Professionals about GIS usage in construction sector**

Due to the lacking of planning and uncertainty about the activities needed to be carried out different types of disputes arises and causes delay to the project. Mainly the consultants and contractors in mass construction has enough knowledge on GIS but due to the cost and not common usage is the issue. Considering about the Colombo Municipal Council (CMC) the involvement or construction sector is high. But other districts the involvement is much lower which needs upgrading the involvement at least up to the level of CMC.

### IV. DISCUSSION AND CONCLUSION

The data collected from different professional whom involved in construction industry has different perspectives. According to their experiences the results of this research has collected. It is clear that the GIS information in a project can be used to visualise and also

for the future constructions that will be carried on that particular location area. Therefore, if there is a method and procedure that have to be adopted in order to make the GIS design. Therefore, if one contractor has design the GIS design it can be used in future projects too. The contractor and his team can finalise the design as well as planning actual activities that has been carried out without uncertainty, without delay in a cost efficient manner. Also the necessity of preparing GIS design and database has to be identified. In the developed foreign countries using GIS databases to identify the soil layers and services such as electrical lines, sewerage lines, water pipe lines that runs underneath the soil. This leads to many advantages for both contractor and to the development as a country to maintain its standards. If the preparation of GIS database about the particular project is essential in every project and entered into the bidding document it also will be an initiative step to implement the usage of GIS for construction sector. As an example if there is a clause to prepare the GIS database and submit it to relevant authorities such as Ceylon Electricity Board, National Water Supply and Drainage Board (NWSDB), Urban Development Authority, Road Development Authority, and Relevant Municipal Council to enter the GIS details about the particular project that the contractor has carried out including its soil details and all other details. Therefore a government policy has to be established and implemented about the creation of a GIS database to a particular project. Another step that can be taken is to insert a definite clause as a general condition to bidding documents. If so, the importance and necessity of a GIS database to the project will be made and sent to the relevant authorities to update their database. From implementing that there will be many advantages. Such as, allowing the public to access to those databases for their construction works will ease their activities that has to be carried out and in planning them. As an example, if a person wants to construct a boundary wall he or she has to be aware about the services running beneath the soil and in some other times he or she needs to get water line the easiest route can be identified easily through the GIS database that has already with the National Water Supply and Drainage Board (NWSDB).

In the constructions of services or buildings nowadays find out the real geographical locations of the elements by using a separate activity since the available surveying data in survey department is outdated which arises so much of unnecessary costs of machinery and tools, costs for labour and time prolongation. Therefore, if this GIS databases implementation will be there the contractor or the person who is going to do the construction can get the awareness

about his site premises and also the neighbourhood site premises since the access to neighbourhood will cause disputes and most of the times it is impossible to carry out trail pits to see what is underneath their soil.

Moreover, in the construction activities such as piling works most of the times that has the vulnerability of causing cracks or any other damages to the neighbourhood around services or other constructions can be reduced and avoided by this GIS database information that will be available in relevant authorities. Another step to formalise this can be used is a unique software or database separately for each authority. If so, the uniformity and reliability will be there. As an example for CEB the GIS design database about electrical lines runs through has to be submitted by the contractor at the end of the project and for NWSDB the water lines and drainage lines designs and a database has to be submitted by the licensed surveyor in that particular project. If a licensed surveyor is not available in the project hiring a licensed surveyor from surveying department. There has to be a standard one version of GIS to be used throughout the country. By that the easiness to work with it can be achieved since everyone will be able to use it and easily manipulate. In purchasing that software some discounts can be allowed to the contractors to increase the initiative of them in using this in their projects. The awareness and implementation advantages of the GIS design and the database is not much in the construction sector and can conduct CPDs at relevant authorities and other organisations involved in construction sector and share information through leaflets and other communication media. It is a requirement for the government as well as a country to uplift the standards that is not available in the country to move forward.

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