SPATIAL INFORMATION TECHNOLOGY AND ENHANCED PROFESSIONALISM: A CASE STUDY OF THE NIGERIAN CONSTRUCTION INDUSTRY – AN EXPOSITORY

Dr. J. B. OLALEYE and J. O. SANGODINA, Nigeria

Key words:

ABSTRACT

Nigeria is one of the developing countries in Africa, and the most populous Black Country in the World. The last records of Meaningful development could be traced to the colonial era when roads, bridges, multi-storey buildings, dams, and so on were constructed.

Then, these structures were constructed to meet the specified British standard, but immediately after independence when the natives took over the administration of this country, the construction industry has witnessed a lot of pitfalls.

Collapsing Dams and bridges, deteriorating road conditions, dilapidating multi-storey structures and so on, thus exhibiting wastage of scarce resources, and sometimes involving loss of lives. Consequently the construction industry has failed to give Nigerians reliable structure that will stand the test of time.

This paper discusses the use of Spatial Information Technology in the design, construction and monitoring such structures.

1. INTRODUCTION

Since the time of creation, man has been known to have a sense of living in a comfortable environment. To achieve this a lot of developments have been carried out over the centuries. These developments have been tailored towards achieving- good roads, drinkable water supply, easy means of communication and transportation, and clean and healthy habitat.

The idea of constructing houses, roads, bridges, and so on can be traced to the time when man developed the instinct to improve his standard of living, historically far back as the Stone Age. Also, the civilization that started in Egypt spread to other parts of the world in a sporadic manner, thus turning the world to what we have today- **" a Global Village"**.

Since man is dynamic in nature, therefore, to achieve his goal of better living condition he surveys different environment before settling down and whenever the condition is no longer conducive he moves to another place.

Surveying is the science on obtaining information about relative positions (on, above and/or below the earth surface) of spatial objects with a view to producing plans, charts and maps. – (Atilola, 1997).

This act of surveying is done by the Surveyor. FIG defines a Surveyor as a professional person with the academic qualification and technical expertise to practise the science of measurement; assemble and assess land and geographic related information; use that information for the purpose of planning and implementing the efficient administration of the land, the sea and structures thereon; and instigate the advancement and development of such practices (Kufoniyi, 1997).

Better still a Surveyor is concerned in knowing <u>what</u> (object/s) is <u>where</u> (space) and <u>when</u> (time) using a field-based or an object-based concept of "reality or real world". (Kufoniyi, 1997). With the new approach to the practise of surveying, the role of a surveyor has been shifted from that of data collector to information managers i.e. "Geoinformaticians".

Surveying information in whatever form is sine qua non for development, and it has been confirmed that the best-mapped parts of the world are the most developed. Therefore, there can't be any meaningful development in any nation without adequate and up-to-date surveying (i.e. mapping). Most of the nations of the world have taken advantage of the recent developments in the technological advances to produce the much-needed maps (Kassim, 1998).

In Nigeria, immediately after independence, the construction industry witnessed a sporadic transformation: new roads were constructed, bridges and multi-storey buildings were built, water pipeline networks were laid, and so on. The purpose was that the populace can easily enjoy and reap the benefits of independence by the different governments.

The most disastrous aspect of it is that since we have the right to rule ourselves (i.e. democracy) nobody cares again for meeting international standards in our construction industry. Projects were awarded, some were executed half way, some no execution at all, and the only few completed ones were not carried out according to the specifications.

The construction industry in Nigeria has really suffered so much especially in the last two decades when the military and the politicians were just using the populace to test their supremacy. As a result of the imbroglio between the two power brokers, a lot of damages and losses had been suffered by the construction industry. The list of the damages done is endless, but some of these damages include: the collapse of Asejire dam, movement of one the most important bridges in Lagos Island (Lagos) about four years ago, the National Theatre in Lagos was noticed to be moving, collapse of a storey building at Maryland (Lagos), exhuming buried facilities, and so on. Several lives have been lost, properties destroyed, material possessions worth billions of dollars have been wasted.

The losses can be attributed to the following problems:

(i) No accurate and up-to-date map to assist in project design

(ii) No qualified personnel (i.e. surveyors) in the construction industry to execute the projects to meet the required standard and accuracy,
(iii) In some cases no adequate preliminary (recce) survey,
(iv) No As-built surveys to show the state of projects after completion,
(v) Finally, no monitoring of projects constructed.

The advances in information technology has placed the surveyor or geoinformatician in the vantage position of more enhanced data capture, data display (in 4-D i.e. X, Y, Z, T), data management, and data analysis and presentation for decision supporting purposes for the operators in the construction industry. Thus, making them to be professional partners working hand in hand.

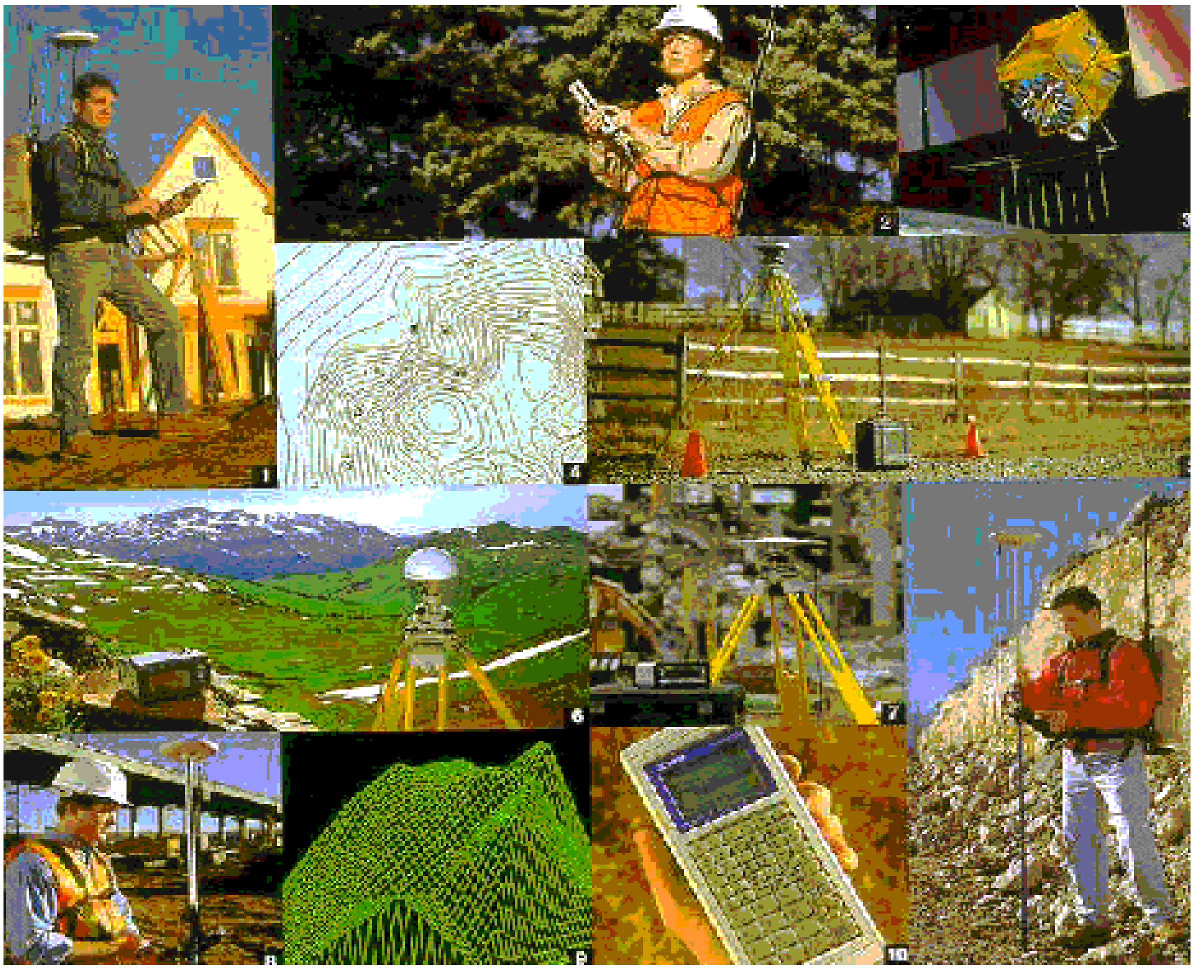

Fig. 1 A Typical Modern Surveying Tool. From Surveying World vol. 5, '97 Jan./Feb.

This paper highlights the need for Engineering Survey Information Systems for the construction industry (ESISCI), creating an (ESISCI) that guides each stage of construction work, and the need for monitoring engineering projects.

2. WHY CREATING ENGINEERING SURVEY INFORMATION SYSTEMS FOR THE CONSTRUCTION INDUSTRY (ESISCI) ?

- At today's complex construction sites, document control, photo cataloging, tracking requests for information and schedule monitoring have become essential parts of fiscally responsible project management. Failures to manage information effectively continue to result in costly delays and errors. ESISCI represent a unique solution to this problem by providing information storage and retrieval in visually and intuitively accessible formats. In the past, contractors have used many different techniques to manage their construction site information. Now, ESISCI offers the opportunity to integrate all these construction documents.

- ESISCI provides tools to help geoinformaticians/engineers (G/E) integrate a variety of data sources and types, maintain and manage inventories, visualize data and related information using dynamic maps, make decisions about engineering project management, and perform modeling and analysis on them.

- By mapping specific components at the job site, ESISCI technology not only integrates project management tools, it also organizes and presents information with previously unimagined accessibility. Instead of relying on the typical database spreadsheet, ESISCI represents information visually and spatially. Rather than searching for that critical bit of information by digging through a spreadsheet, ESISCI allows you to click on a drawing of where that information relates to for immediate access to all pertinent documents.

- Surveyors and engineers understand the importance of geographic data. Surveyors use precise instruments, procedures, and computations to accurately locate and define geographic features while conducting field surveys for engineering projects. Engineers design and build structures/infrastructures on geography measured by surveyors.

Other benefits are listed below:

- ESISCI improves data recovery and limit confusion in the field through the use of laptops.
- ESISCI produces easy-to-read maps with links to data files for both management and superintendents.
- ESISCI makes it possible to easily and affordably integrate previous data into the new database management system.
- ESISCI will enable one to map and access data for a visual history of your project.
- ESISCI helps to tracking request for information (RFI's) thus eliminating costly construction delays.
- ESISCI can easily be applied to facilities management and life cycle costing of engineering projects.
- ESISCI can facilitate survey crew daily log management through the use of a powerful database management system.
- Most importantly, ESISCI can be used to project the future of construction management and guide in decision-making.

A well comprehensive Engineering Survey Information System for the Construction Industry (ESISIC) can assist engineers in the following ways:

a) **Route investigation and site location planning —** Investigating sites, collect and assemble all pertinent information and analyzing environmental issues. That is, route or site selection in order to get the best possible location.
b) **Buried facilities location** — On-site investigation of facilities location through the database in the laptop in order to avoid exhuming buried facilities.
c) **Deformation surveys —** Gives information on the difference between the states of structures as at the time of construction with time.
d) **Construction surveys/As-built —**Provides information on setting-out plans and will provide the as-built data required for ensuring compliance to design specifications, quality control and material reconciliation.
e) **River scour and buoyancy surveys —** Provides optimal routing selection and information required to assess and design river crossings.

3. CREATING THE ENGINEERING SURVEY INFORMATION SYSTEMS FOR THE CONSTRUCTION INDUSTRY (ESISCI)

Before any project is constructed there must be proper planning, and there cannot be any tangible planning without the survey plan of the area concerned.

This survey plan is produced by a surveyor/geoinformatics who depends on any previous information of that locality that is available to him and based his new task on it. He starts from "Whole-to-Part". Depending on the method he wants to adopt, he goes right ahead on gathering the required data provided he has competent personnel, modern equipments and the where – withal to meet the needs of the method.

The various stages of producing the required digital survey plan are discussed under the following: Data Acquisition, Database Management System, Analysis and Presentation.

3.1 Data Acquisition

Traditionally, data capture is accomplished by survey methods such as ground (land) survey, photogrammetry, remote sensing, and hydrography. The data processing entails rigorous computations and the presentation is always in analog (map) forms.

But with the advent of information technology, data capture has become very interesting and challenging. Within a spec of time data can be captured by using GPS, Total Station, and Satellite Technologies (with few personnel), while data processing is quickly done using powerful computers (mini or macro) and with the aid of geographic information systems GIS as a tool the map can be either in digital form (saving space) or analog form. Consequently, the time for producing the required survey information (data and/or maps) for developmental and management purposes has greatly reduced.

The Ground Survey Method includes traditional land surveying methods such as traversing, triangulation, trianlaleration, spirit levelling, trigonometric levelling, tacheometry, compass traversing, chain surveying and a combination of some of these methods. **Photogrammetry** makes use the techniques of interpreting aerial photographs. **Remote sensing** is a method of collecting information about objects or the environment without coming in contact with such objects. **Hydrographic method** supplies sea-related data e.g. depth of sea at a point, tidal height, etc. **Global Positioning System (GPS) method** supplies the geo-data of any particular point(s) by tracking artificial satellite e.g. NAVSTAR GPS, SPOT, LANDSAT, etc.

For engineering works that require precise survey e.g. Dams, Road construction, Bridges, Laying of pipes, Mining Operations (tunnels), to mention but a few, the fast and accurate data acquisition methods are Remote Sensing, GPS and the use of Total Station.

The route/site field survey is carried out using any of these methods or a combination of some of them. Each terrain object that is to be coordinated in the construction industry is described by three main components- namely the geometric components, the attribute (non –geometric) component and time component.

- The geometric data consist of the objects location, its spatial relationships with other objects in the geographic space and its shape and size. For example, Lagos – Abuja Road having X, Y, Z; X', Y', Z', coordinates or Administrative Block "A" is located at X, Y coordinates having Z height.
- The attribute component refers to the observed facts about the object such as the identifier of a land parcel, its use, name of owner, the encumbrances on the land, its value, etc. For example, Route Identification Number is "AB 145", Secondary Road, Constructed by Federal Government, No encumbrances, 1.8 Billion Naira, etc.
- The time component takes care of such questions as <u>when</u>? i.e. when was the cut and fill done? When was asphalt laid? When was the road finally completed? What was its condition now? Time establishes the state of structures/infrastructures at a future time.

In the construction industry the geometric data are very essential resulting in what is called Digital Terrain Model (DTM). Queries such as "on which soil layer is the building located?" can only be answered by a 3 – D reference system. The third component i.e. Time is very essential so as to monitor projects that have been constructed. While the Attribute describes textually the object and its location.

The data to be captured here includes, planimetric coordinates (X, Y), height (Z), extent of coverage, information about locality, time (year) of construction, soil texture, etc. These are essential ingredients for the maintaining the project.

3.2 Database Management System

The geometric, attribute and time data collected above are well arranged and stored in the computer in an organized manner. Files containing relevant fields and records are created for:

- Initial Survey,
- Setting Out data,
- As-built Survey, and
- Monitoring Survey.

The data stored above can be manipulated in a lot of ways to suite the requirement of the end user. For example:

(i) Calculating the length of a proposed road between two coordinated points,
(ii) Calculating the area of site involved in a proposed construction,
(iii) Calculating the volume of earthwork to be excavated or filled,
(iv) Calculating the capacity of a dam,
(v) Calculating the weight of a bridge connecting two locations together,
(vi) Calculating the depth of tunnels,
(vii) Calculating the height of towers and multi-storey structures,
(viii) Calculating the amount of deformation that has taken place over a period of time, and so on.

The following modes of data processing are possible:

- Real Time Processing, Post Mission Processing, Adjustment and Transformation, and Network adjustment.

The following data analyses are also possible:

- Statistical, and Graphics display functions (for topological overlay, buffer generation, adhoc query and modeling, etc.). This can easily be used for visual analysis of the amount of deformation of the structure over time.

3.3 Presentation

Information presentation apart from technical report writing can be in two forms – analogues or/and digital. Whichever form the presentation takes a well-designed SISCI should give geographic, attribute and time information to the consumer in a clear form without any ambiguity.

The various output of analogue form of information presentation include:

(i) Topographic maps (usually large-scale type) i.e. the <u>initial survey map</u> (plan prepared as a result of the original site/area survey.
(ii) Route maps (also large scale), these consist of (a) the <u>working plan</u> produced by the engineer; showing the location and form of the new construction sited on the survey plan, (b) the <u>setting-out plan</u>, showing the relation between the recovery pegs and the pegs defining the position of the new works, and (c) the <u>record pans</u> also known as <u>as-built plans</u> and <u>as-laid plans</u>. The latter term is applicable to pipelines. The As-

Built survey shows the deviation of the new project as finally constructed from the design. These type of plans are usually for updating the database.

Information can be presented in digital form in the following ways:
(i) Computer Assisted Drafting/Cartography CAD/CAC,
(ii) Computer Aided Mapping CAM, and
(iii) Geographic Information Systems GIS.

It is very unfortunate that almost all engineering projects done in this country has no <u>"As-Built or As-Laid Survey Plan".</u>

4. IMPROVING THE DESIGN-REVIEW PROCESS

After the setting-out plans have been produced. A great gap can be created during the actual setting out of the design on the ground. This gap of anomaly can be taking care of if there is an <u>"improving on the design-review process"</u> in place. This is a stage in any construction project that has not been considered in Nigeria. In the "improving on the design-review process", the following things are taking care of:

- The review of partially completed projects prior to completion of the project in order to identify errors, omissions, and inconsistencies,
- It increases the cost-effectiveness, timeliness, and overall quality of the completed construction project i.e. thus reducing/eliminating wastages,
- In addition to contractor's concern, environmental issues overlooked during the design phase but are having impact on the execution of the project can easily be integrated at this stage. <u>NOTE-</u> Environmental compliance issues outside the control of the engineer/architect and the construction team have suspended if not stalled construction in the past,
- Components and building systems that are difficult to maintain and operate are identified before its too late, and
- It allows information to be drawn from a similar past experiences, standard references, and other previous data.
- For maintenance team, "design-review process" allows them to keep systems operational in order to guide against use of fake construction materials,

All these searches can easily be done where there is a computerized information system such as Engineering Survey Information System for the Construction Industry (ESISCI).

5. MONITORING

Monitoring is the act of keeping accurate record of something or an object. Therefore, monitoring engineering projects is the process of keeping a constant and periodical record of any engineering project. Monitoring these projects enable the following to take place:
1. Provides checks on a project,
2. Provides control of a project, and
3. Gives warning on a project before it collapsed.

There is no justification in spending so much resources and time on any project and allow the project to collapse under a short time instead of monitoring it in order to maintain it and avoid great loss.

The following are some of the basic causes of structural movement experienced by completed projects:
- Nature of the type of soil on which the structure is built,
- Nature of the type of materials used in the construction,
- The Design Plan (may be faulty),
- Quality of the personnel that did the setting-out,
- Quality of the personnel that actually constructed the project,
- Earth movement,
- Weather situations,
- Use of the structure e.g. an industrial building, buildings in densely populated areas, and
- Age of the structure.

With these conditions it is clearly possible to see structures moving away from their original position. Structures can move horizontally, laterally and vertically, and these can be up to some metres.

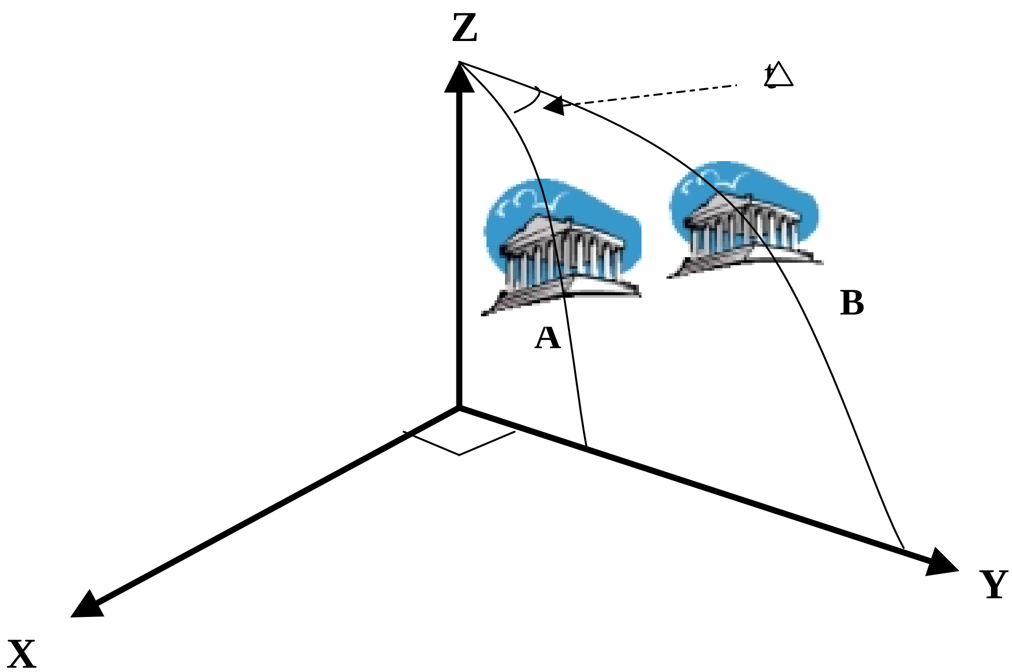

Fig 2. shows the 4-D position of a building that has experienced displacement.
- At time t_1, the building was at A having X, Y, Z, t_1 coordinates
- At time t_2, the building is now at B having X', Y', Z', t_2 coordinates.

The differential in time t2 – t1 = △ t has caused the movement of the building from point A to B, this movement no matter how infinitesimal is very important to the engineer because if provision is not made for this shift the repercussion may be too grievous. Multi-storey buildings, Dams, bridges and tunnels have collapsed killing or injuring a lot of people as a result of lack monitoring team.

6. CONCLUSION AND RECOMMENDATION

In brief, from the reasons highlighted in the above paragraphs, it can be seen that creating an engineering survey information system for the construction industry (ESISCI) will bring about the following benefits:

a) New and flexible forms of output such as customized engineering maps in digital or analog form, reports, address list etc;
b) Quick and easy access to large volume of engineering data;
c) The ability to select terrain detail from the database by area or theme (e.g. project type);
d) The ability to merge one data set with another;
e) The means to analyse spatial characteristics of data;
f) The means to visualise designed projects in 3-D before its construction;
g) The means to search for particular characteristics or features in an areas;
h) The means to update data quickly and remove redundancy

The following recommendations are hereby suggested:

(i) Formulating a policy, making it mandatory that a Registered Surveyor/Geoinformatician must sign all setting out plans.
(ii) All construction companies must be mandated to employ a Geoinformatician/Registered Surveyor or a graduate of surveying to man the Survey/GIS Department of such companies.
(iii) A policy must be formulated enforcing all construction companies to create a surveying information system for the construction industry (SISCI) in their survey departments.
(iv) A policy must be put in place to make sure that all projects valued at N500, 000 and above must be monitored to avoid collapse of such structures.
(v) A policy making it mandatory of any government establishment, be it parastatal or not, must not award any contract that involves survey activities to just anybody but only to Registered Surveyors/Geoinformaticians.
(vi) Engineers are to make provision for the "improving on the design-review process" to take place,
(vii) "As-Built Survey" should be made a compulsion, and
(viii) Since Surveyor is the first man to work on any site earmarked for developmental project, therefore his name must appear on the bill board of all the contractors during the construction or execution of the project.

It is our belief that if all these are put in place; the losses experienced in this country (Nigeria) through collapse of bridges, buildings, dams, and washing away of roads.

REFERENCES

1. *Kufoniyi O. (1998):* "Basic Concepts in Geographic Information Systems (GIS)". From Principles & Application of Geographic Information Systems- a series in Surveying & Geoinformatics. Published by Dept of Surveying & Geoinformatics, University of Lagos, Nigeria.
2. *Sangodina J.O. (1999)*: "Creating a Prototype Intelligent Vehicle Highway System (IVHS) using GIS: A Case Study of Lagos Roads. An M.Phil. Thesis, Dept of Surveying & Geoinformatics.
3. *William East E., Roessler T., & M. Lustig (1995):* "Improving the design-review Process". Journal of Computing in Civil Engineering, Oct. '95 vol.9 No.4. Pp229-235.
4. "Using GIS to Manage Your Construction Projects: New Tools for Old Problems". University of Washington, College of Engineering web site.

CONTACT

Mr. J. O. Sangodina
Dept. of Surveying & Geoinformatics
Faculty of Engineering
University of Lagos
Akoka, Lagos
NIGERIA
Email: joolusina@yahoo.com