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The Built Environment: Innovation Policy and Sustainable Development

Edited by: I. A. Okewole, S. A. Daramola, C. A. Ajayi, O. A. Ogunba, K.T. Odusami

THE ROLE OF TECHNOLOGY IN THE BUILT ENVIRONMENT

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Abstract
Lately, the built environment has been witnessing a lot of hazards ranging from collapsed buildings and bridges, floods and typhoons, droughts and landslides, as well as fire, tsunamis, hurricanes and earthquakes. Others are hazards launched through technology such as bio-terrorism and cyber-terrorism. Thus, necessity is place on Architecture, Engineering and Construction (AEC) industry to prevent the "sick building" syndrome and make the built environment safe, secure, and healthy for mankind. This paper attempts to examine the immediate and remote causes of fail and sick buildings with a view to proffering solutions through the use of technology. Furthermore, the paper presents the application of the available technologies such as e-construction, Geographical Information System (GIS), Computer Aided Design (CAD) and the Global Positioning System (GPS) to the built environment. An integrated design environment within the AEC industry is proposed to allow for modeling, designing, analyzing, and visualizing structures. Thus, the behaviour of structures can be modeled through "virtual reality", leading to the creation of "smart buildings", which are design concepts for this generation.
Keywords: Bio-terrorism, Virtual Reality, Smart Building, E-construction, and GIS/CAD

Introduction

The built environment is composed of the buildings, spaces, places and structures where human beings live, work and play. That is, the house they live in, the office, factory, school, and shop they work in; the gym, café, and playground they socialize in; and the connecting space between these places (Craig, 2005).
It was observed that people spend at least 90% of their lives indoors, therefore making it imperative for the building professionals to ensure that the man-made environment is neither injurious to human health nor hinders human performance (Russell, 2002a). The interactions between the built environment and its inhabitants must be given prominence. The issues of human health and performance, urban ecosystems, environmental systems research and safe building technologies must be well considered.
Throughout history, scientists and engineers have been saddled with the responsibility of protecting and supporting the society. Arising from the various threats to lives within the built environment, there is the dire need more than never before for technologies and systems that can sense, identify and respond to threats to homeland security.

Science and Technology has helped produce the mechanism through which designers understand the mechanism of natural hazards of atmospherical, geological, hydrological and biological origins as well as helped mankind with the means to analyze the transformations of the hazards into disasters (Badaoui, 2001). It has helped develop scientific knowledge through studies, experiments and observation of floods, severe storms, earthquakes, landslides, volcanic eruptions and tsunamis, and their impact on mankind.
Therefore, making the built environment safe for mankind calls for concerted interactions among the various professionals as:

a. Scientific/Technological discipline (basic engineering, sciences, natural, social and human sciences)
b. Hazard environment (hydrology, geology, geophysics, seismology, volcanology, meteorology and biology)
c. Built environment (engineering, architecture and material)
d. Policy environment (sociology and humanities)

In the construction industry for example, the architect produces the architectural designs, showing the various space allocations, elevations and renderings; the structural engineer based on these designs performs the structural analysis viz the behaviour of such structures under loads and evaluates deformations, stress and strain; and thus propose the strength of materials needed (Gbadeyan, 1996). Finally, the quantity surveyors prepare the bill of quantity based on the findings of the structural engineer. The same holds for the electrical engineer who prepares the various electrical designs for the structure.

The Chanllenges of The Built Environment

The incessant cases of collapsed buildings and bridges and the September 11 (9/11) saga in the US have necessitated the need for new ideas from the Architecture, Engineering and Construction (AEC) industry to ensure enhanced security in the buildings we live, work and play (Russell, 2002b). The AEC industry should prepare for the worst situations in designs, and should develop and implement systems to prevent adverse consequences. The effect of collapsed structures is so enormous that engineers cannot rely on standard specifications, and code of practice available within the district, to determine the size of structural members that resist tension, compression, shear and bending (Gbadeyan, 1997).

The threat of bio-terrorism has been paramount in the agenda of world leaders as manifested in the Iraqi war, Pakistan and Iran wars. To prevent bio-terrorism requires a thorough knowledge of the agents as well as putting adequate measures in place to prevent its introduction and spread.

Lately, the world has been witnessing a great threat to the built environment. The tsunami in Indonesia where over 126,804 people were reported dead, around 93,458 people missing, 474,619 people displaced, and the total damage put between $4.5 to $ 5billion. Others on the international arena include earthquake in Pakistan and hurricane in the US among others that resulted in monumental loss of lives and property (Anonymous, 2005).

It has been widely reported that flood is the most common of all environmental hazards. It is responsible for about one-third of all deaths, one-third of all injuries, and one-third of all damages from natural disaster (Ologunsorisa, 2005). In Nigeria, we witness incessant attack on the built environment from: flood- the Jalingo saga; pipe-line vandalization within the Niger-Delta, and the western coast; as well as environmental degradation requiring huge sums of money to address.

Technology And Aec Profession

Technology has a great role to play in making the built environment safe for mankind. Much emphasis is placed on the fusion of information systems and sensor technology in the design of structures as well as maximizing building security while minimizing disruptions to occupants (Russell, 2005b). Since risks cannot be completely eliminated, the only option left is to manage it appropriately. Science may not be able to prevent earthquake, but accurate forecast can be made to give warnings through the adoption of adequate technology. Warnings on violent storm and volcanic eruptions (given in hours/days) to prevent loss of lives and property. In the construction engineering, earthquake-resistant structures, including high-rise buildings, critical lifelines and industrial facilities are made available through technology (Badaoui, 2001, and Geoff, 2000).

The other specific areas/technologies are:

E-construction

This technology involves the CAD system, Internet and project management tools. In addition, it includes autonomous machines and field robotics- driverless trucks, crane, compacters, site robots for spraying automatic masonry and pipe laying robots, and heavy lift tool deployment manipulators to position steel beams or pre-cast concrete panels (James, 2000).

Similarly, there are autonomous road building equipment fitted with CAD, combined with global positioning technology or distance operated information systems to build roads in remote locations.

This technology has already been tried abroad.

(a) A driverless load haul dump vehicle manipulates a tunnel with 150mm clearance either side at 20km/hr. It has a laser scanner on the front to detect unprogrammed obstructions.

(b) A self-programmed excavator and a robot to demolish a nuclear reactor.

(c) A masonry lay robot in Spain, working from CAD drawings to construct a building with cameras on helmet of on-site building workers receiving instructions through engineers with remote site inspection.

Thus with e-construction, builders on the side of technology have the competitive edge over others. Similarly, one can build up a good customer relationship and regional alliances, link-up clients to the web or extranet, use project management tools as well as present the many faces (views) of the structure to clients.

Computer-Aided Design (CAD)

This involves the use of computer system in drafting and designing of structures. It has revolutionized the process of analysis, design, testing and manufacture. Most CAD packages can be interfaced with a lot of other ones for performing mechanical, civil and electrical designs and analysis. Similarly with CAD, complex structures such as ships, earoplanes, buildings and spacecraft that are hitherto contractile in nature can be modeled and analyzed (Gbadeyan, 1996).

Geographic Information System (GIS)

A GIS is a decision support system designed to work with spatial information that shows roads, population, sewer systems and the layout of electrical and other notable structures in map form. GIS can help determine the best place to situate a proposed structure. It is well-suited for storing, retrieving and analyzing geographic data to support the decision making process. GIS can be employed to develop a well-structured layout of a country detailing proposed bus, van, light-rail routes, sewage, and underground pipeline the best way possible (Haag, 2000).

Global Positioning System (GPS)

The GPS is a collection of 24 earth-orbiting satellites that continuously transmit radio signals that helps to give the relative location of the carrier. It picks radio signals from the four of the satellites to give the location of the carrier within a few hundred feet.
This device is employed by surveyors to take the coordinates and the perimeter of a landed property. It simplifies the task of land surveyors.

The Integrated Design Environment

The integrated design environment offers a cheaper means of accomplishing data visualization, design and analysis of structures on Personal Computers. It offers inter-application communication; enhanced unified engineering database made available to all the principal objects; and enhanced possibility of a lot of "what if" scenarios on the structure in other to obtain the best practice (Ayo, 1999, and Ron, 2003).
The advent of the "Convergent technologies" which involves the convergence of nanotechnology, bio-technology, information technology and new human technology based on cognitive science has promised a tremendous improvement in the quality of life and society. This is aimed at designing the built environment to reduce crime, enhance communal child rearing, and foster high social interactions (Hellen, 2001). The available technologies for integration include: virtual reality and smart building.

Virtual Reality

Virtual reality planning and analysis technologies are used to build factories in 3D, assess performance and fine-tune structures before any brick and mortar are laid. Thus, computational sciences and engineering relies on scientific visualization to present solution by turning massive amount of data into movies and graphical display measurements of physical variables in space and time.
Virtual reality software shows 3D rendering; display the behaviour of the structure under load; and has helped herald the death of distance, the irrelevance of size, collaboration and not confrontation (Anonymous, 2004, and James, 2000).

Smart Building

The intelligent building systems offer utmost comfort by optimizing temperature, indoor air quality, lighting conditions as well as security. The technology responds to situations and users' needs. It is an automated system that meets users' requirements.
The Connected Open Building Automation (COBA), which is a building operating system that offers a common interface to all facility management systems. The system regulates: heating, ventilating and air conditioning (HVAC); lighting, access, attendance and material consumption; video surveillance as well as burglar, fire and humidity alarms (Schaffner,1999).
Smart buildings integrate control technology with the building system. It anticipates the users' needs to provide improved comfort, greater user control, and better efficiency (Gbadeyan, 1997, and Anonymous*). The system involves:

(a) A web-based control of buildings: occupants can adjust room temperature, change lightings etc.
(b) The integration of HVAC, lighting system and security system: it tracks visitors to the office or workers outside official working hours, it turns off/on lights and HVAC in areas used or not used.
(c) Smart windows: It controls the louvers and the HVAC. Thus if the window is opened, it turns down the HVAC system.

Energy-Smart Building

The Americans adopted the EDUPLAN: a hemispheric plan of action for the reduction of vulnerability to the natural hazards in the education sector. This is a consensus-building process by the Organization of American States (OAS) (Nguten, 2001).
In the same vein, the energy-smart building integrates energy savings strategies into the design of buildings, particularly schools. The concept is aimed at maximizing solar access to boost effectiveness of day-lighting strategies by reducing electrical lighting, heating and cooling (Anonymous, 2001). Schools can be designed to reduce total dependence on public power, water and gas as well as making the environment healthier for human life.

Integrated Design, Visualization and Analysis of Structures

This integrated design environment is composed of three different objects brought together to ameliorate the level of hazards facing the built environment. Autodesk AutoCAD is the design platform, considering its popularity, Visual Basic offers the platform for analyzing the behaviour of the structure and MS Excel is the Visualizer.

The integrated environment fosters inter-application data transfer through Dynamic Data Exchange (DDE) and Object Linking and Embedding features of Microsoft Office.

Fig. 1 Data Flow Diagram for the Integrated System

Autodesk Revit is a new development over AuoCAD. It offers an integrated state-of-the-art building information medeling system. Revit stands for "revise instantly". It is a powerful design and documentation system delivering competitive advantage; improve coordination and quality and higher profitability to architects, builders, and other building industry professionals.

Revit offers visualization and presentation facilities as well as providing export for building information model to industry standard open database connectivity (ODBC) compliant database tables. This has further simplified the integrated environment for professionals to perform the needed analyses, experimentations and quantifications.

Recommendations for future designs.

The demands of this generation require that researchers drive discovery process and navigate or steer their calculations in real-time fashion. There is need for on-line interaction with the field data to perform "what-if" analysis on them, and explore the various possibilities on the models to forecast their behaviours under certain conditions. Thus, future designs require that:

a. Virtual reality technology be employed to predict the behaviour of structures under certain conditions.
b. The history of the location be investigated. This may include the seismic data from geological survey to determine if it is prone to natural disaster.
c. The concept of immune building that incorporates a biosensor technology be integrated to detect and neutralize the effect of bioterrorism.
d. Smart building concept be incorporated that observes certain environmental factors and through predictive modeling and decision-making algorithms choose the most effective responses to protect occupants.
e. There be an improved indoor air quality by minimizing the use of volatile organic compounds in paints, carpets and adhesive, as well as the formaldehyde in plywood, particle boards and cabinets.
f. There be integration of water conservation scheme through rainwater collection system to provide water for toilet flushing and irrigation.
g. There be incorporation of recycling systems and waste management strategies to reduce the amount of landfill waste.
h. There be improvement in environmental pollution through the use of natural gas, biodiesel, methanol and solar electric buses.
i. Geographic information system be used to make available to designers the atmospheric and seismic data of the location.
j. GIS and GPS and the satellite be used to make available the data of the disaster areas and can be correlated with the data of the site where that structure is to be located.
k. Finally, the concept of Total Quality Management must be introduced into all facets of design, construction and finishing. This will reduce the incessant rate of collapsed buildings

Conclusion

The built environment will continue to be plagued with lots of environmental hazards and only technology has the respite from these. Thus, there is need for a fusion of the AEC professionals to cooperate and collaborate on a safe and healthy environment. Therefore, through an integrated design, analysis and visualization or virtual reality the many faces of the structure can be viewed under different loads to predict its behaviour in reality.

Similarly, the need to reduce poverty by 50% as championed by the UN through the MDGs demands an efficient use of facilities such as energy, water by integrating HVAC, lighting and security into designs. Thus, through VR, smart building, CAD, GIS and GPS; and a rigid Total Quality Control measures, structures can build to last and for safety.

In Nigeria particularly, cost of facility expansion is unnecessarily high due to lack of adequate plans for future developments. Hence it is high time the building professionals embarked on digital plans with layout for expansions (waterways, railways, motor roads, government reservations, schools etc) years ahead. Thus development can be cheap without having to pay for neither demolitions nor compensations for relocations.

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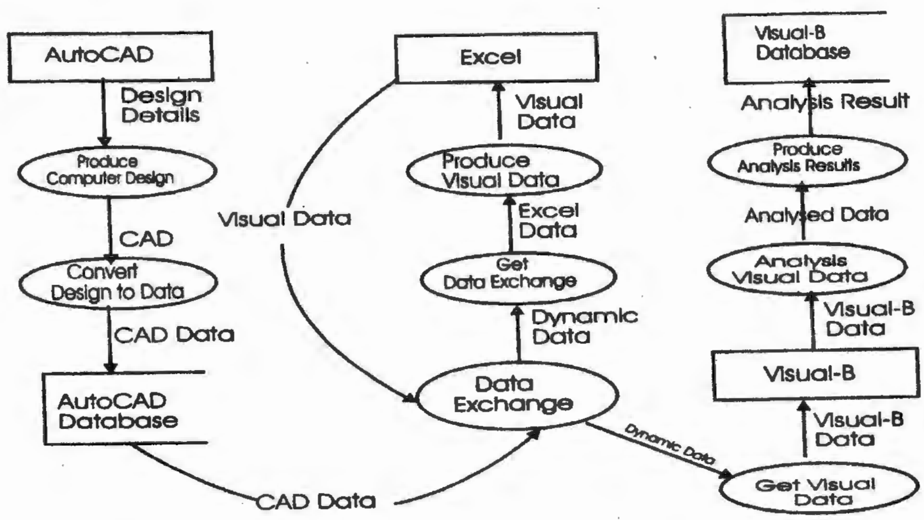
AutoCAD
Design Details
Produce Computer Design
CAD
Convert Design to Data
CAD Data
AutoCAD Database
CAD Data
Visual Data
Excel
Visual Data
Produce Visual Data
Excel Data
Get Data Exchange
Dynamic Data
Data Exchange
Dynamic Data
Visual-B Database
Analysis Result
Produce Analysis Results
Analysed Data
Analysis Visual Data
Visual-B Data
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