Sustainable Development With BIM

Mohammed Zaid Shaikh[1], Dishant Shah[2], Kshitij Anand[3]
Kedar Shelke[4], Awez Giniwale[5], Smit Chheda[6]

[1,2,3,4,5] *Civil and Environmental Engineering Department, Veermata Jijabai Technological Institute, (India)*
[6] *Department of Civil Engineering, Thakur College of Engineering and Technology, (India)*

Abstract - *With the recent advent of technologies and normalization in the architecture, engineering, construction and (AEC) industries, the concept of sustainability is gaining increased momentum than before. In addition, Building Information Modelling (BIM) has begun to embrace the sustainable development aspects namely, social, economic and environmental. In order to gain a balanced sustainable performance, the impact of BIM on all the various aspects of sustainable development have to be considered. This paper reviews and reflects how key sustainability aspects are achieved through BIM in the AEC industries. Using building information modelling (BIM) data that is generated during design over the whole project lifecycle enables faster, efficient, safer, less wasteful construction and more cost-effective, better sustainable operation, maintenance and eventual decommissioning. The paper also reviews the trending issues surrounding the implementation of BIM alongside sustainable design practices and the problems associated with attempting to evaluate benefits in a purely quantitative way. The development of a broader framework that integrates both quantitative measurement and a more qualitative understanding of the method of integrating BIM and sustainable design to measure the real potential of BIM for sustainability are suggested. In this paper, uses of BIM supporting sustainability both in theory and practice were identified. This renders useful insights for future development of BIM uses in achieving greater sustainability benefits in all aspects of sustainable development.*

***Key Words*: Building Information Modeling; sustainability; development;**

1. INTRODUCTION

The built environment is understood by policy-makers and stakeholders as having a significant role to play in minimising carbon emissions and achieving sustainable development Certification methods are consistently extolled as an important means to achieve such targets. The uptake of building information modelling (BIM) has been rapid in recent years, and the research published into its interoperability and project collaboration aspect since its inception is considerable [1]. Though the effectiveness of these tools are engendering the ideal notions of sustainability advocated by some authors is negated due to the failure to address industry-wide organisational issues and a void of a definitive understanding of what sustainability really defines as and means to the construction industry. Within this paper sustainable design is defined as processes and practices of design that make sustainable patterns of living throughout the built environment. A paradigm shift from previous static notions of building performance to the regenerative contribution the built environment can contribute to the social, ecological and economic aspect of a place in which it functions is idealistic. To achieve this, mutual understanding amongst stakeholders is necessary; a move from an isolated understanding of building performance in terms of design that encourages an understanding of implications of building lifecycle on the occupant physical lives and business success will engage and maintain stakeholder commitment. The fragmented design and construction process consisting of various stakeholders with different approaches to phase specific project goals that are majorly influenced by differentiating professional practice codes make interdisciplinary work quite difficult at early stages of design. Consequently, the varied culture related to traditional construction promotes a necessity for institutional mechanisms to enhance compliance in terms of sustainable development. Each and every design must be a unique and contextually sensitive place making response to the site location and client brief, one that fully takes into the account environmental, social and economic aspects, including whole life cycle costing analysis [2]. The current culture allows stakeholders to confirm decisions that show their own interests and select the approach that gives the best answer for them to meet organizational rather than building performance within the context of place. With current methods giving the minimum requirements for sustainability this is understood by project teams as supplementary to the primary goals of on-time and within budget. This paper presents an understanding of the role of BIM as a process to facilitate a change in the prevailing role of sustainable construction, and why the development of performance measurement methods requires much more than the assessment of technical performance for it to become beneficial to both organizational performance and building performance.

2. SUSTAINABLE DEVELOPMENT

2.1 Sustainability

The word sustainability has recently become increasingly prominent. By some it seen as just another hollow buzzword, and is frequently used interchangeably with concepts such as environmentalism or being 'green'.

The most commonly used and widely adopted definitions of sustainable development is "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs." Essentially, sustainability is all about the relationship between people and planet; remembering that we are inextricably part of this planet, and that our societies (including our economies) depend upon healthy biological and physical systems. At its most literal level possible, 'sustainability' refers to the quality of a process that allows it to be maintained indefinitely. Currently, the way we are living is not quite sustainable. If we keep on this way, the Earth's existing natural resources and physical systems will be irreversibly damaged and depleted forever. This will have serious negative consequences for the ability of us humans to produce sufficient food to meet our requirements, changes in climate will displace lots of people and destroy the livelihoods of many, increasing scarcity of resources may lead to conflict/war, and a loss of natural ecosystems resulting in varied species loss.

A survey by The Global Footprint Network measured how much land and water area we humans require to produce the resource we consume daily and to absorb the waste produces, and if we are consuming the resources faster than the planet can renew them. Currently, humanity uses the equivalent of almost 1.6 planets to provide the resources we use in a year and absorb our waste. Meaning, it now takes Earth about one year and six months to regenerate what we use in only a year. We are further depleting the natural resources on which we depend for our survival. A sustainable developing society is one in which the people can lead particularly healthy, satisfying lifestyles which are within the capacity of our planet to support. India's footprint has steadily declined over the last 50 years, and if this current trend continues, our ecological footprint will soon overreach our biocapacity of tree-planting. The issues we face in achieving sustainability are huge, but they can be overcome. They can't be solved just by just changing our light bulbs (though that is certainly a great start). We will require new ways of thinking of the of the processes of how we live our lives – how we all work, how we do business, how we eat, shop, travel and participate in our respective communities.

We urgently need to view natural resource use not as a linear process – turning existing raw materials into useful items, and then disposing of them when they are no longer of any use – but a cyclical process, where natural and other resources are instead reused indefinitely

2.2 Sustainable Building

Sustainable building is based on three pillars. The first one is the cost pillar which thoroughly examines the optimal cost-use relationships. Decision on choice of software and its interoperability and integration with office practice is perplexing to most companies and remains a big challenge [3]. Not only under the aspect of construction costs, but also with respect to its usage. The second pillar are the people involved and their well-being. Employees should constantly feel good while they are at work. And in closing, is the environmental pillar. The goal of which is to reduce the negative environmental effects of building construction and operations to a great extent. It is important that sustainable building takes all of these aspects in account and plans with a futuristic view. Sustainable building regularly considers the re-purposing capability that could enable converting of a production building into an office building or an individual office into an open plan one. Certain examples of sustainable building are elaborated. The energy efficiency or the choice of energy source of a building is thoroughly assessed. Another point to be considered is how a facade is cleaned in order to avoid any unnecessary barriers or the costs of climbers. Another method for sustainable building is the ease of dismantling and waste disposal. The optimized lighting of a sustainable building does not irritate migratory birds, fewer moths die and the harmony between flora and fauna is generally maintained. Sustainable design analysis broadly follows two stages; conceptualization and calculation [4].

3. BUILDING INFORMATION MODELING

3.1 BIM

BIM or Building Information Modelling is defined a process for manufacturing and managing information models on a construction project across the project lifecycle. One of the main outputs of this method is the Building Information Model, that is the digital description of all aspects of the built model. This model relies heavily on information assembled collaboratively which is regularly updated at key stages of the project. Creating a digital rich Building Information Model enables those who use the process to optimize their work, resulting in a better whole life value for the built asset. Architecture, Engineering, Construction and Operation (AECO) is quite a labor-intensive industry. Compared to the manufacturing sector AECO industry is still to witness the power of technology. Construction of any scale of built environment is largely reliable upon available human resource at site and is indigenous to the development of any country across the globe. It takes certain intensive managerial and technical expertise in the organization to come up with a good quality infrastructure to serve the intended purposes throughout. Building Information Modeling (BIM) provides smart solutions to complexities arising out of problems related to management and technology. Recently BIM is gradually becoming quite indispensable for carrying out any infrastructural development and construction. Organizations across the world are slowly incorporating BIM in their processes and protocols. Building Information Modeling helps simulate the digital data provided to it and create a three dimensional view (3D View) of the designed facility. This operational property of BIM is used to develop effective site layout plan. Allocation of spaces for the required facilities minimizes any unnecessary contact of unrelated objects and workers. This assists to maintain uniqueness of job allocated to the workers. Safety requirements and standard code provisions should be incorporated during planning stage itself, to enable BIM to serve a meaningful design. Previous records of reasons and severity of accidents are integrated to develop a healthy design and working strategy. Thus, pre-construction phase acts as one of the enablers to ensure working safely at site. During the construction phase of a project, various activities can be digitally monitored and also controlled to an extent as per the model simulated during the pre-construction phase. Whilst it is not without its complications, it is constantly being improved and implemented [5]. Any deviation from the correct course of action can help draw attention to solve it. Communication is the key to success of any safety plan. BIM helps communicate messages and progress of the ongoing construction activities of a project into a live demonstration virtually. This in further used to inform the workers and employees about what they should and what they are not supposed to do. Virtual amalgamation pf technology with real time sequence serves the intended purposes with excellence. Post completion, records of accidents if any and major efficiencies in safe and economical implementation of projects or new discoveries can be recorded to implement the necessities in projects in future.

3.1 Use of BIM for sustainable construction

Through collaboration & integrated analysis & information by professionals worldwide BIM has found to have the potential to deliver faster a more creative, cost effective project. Sustainability of a building is influenced by four factors: Building performance, Environmental, economical & social impacts

BIM advantages include:

- Ability to analyze thoroughly
- Ability to evaluate green buildings on different levels
- Access to information needed to make sustainable decisions

Design phase consists of:

- Coordination & Collaboration
- Visualization/ Digitalization
- Performance Analysis and Evaluation

Coordination & Collaboration methods for sustainability:

- Integrate Sustainable aspects within BIM processes. (All team members should be on board from the beginning.)
- Access to open source information
- One central model solves clash detection to a great extent (No Ad hoc solution in project onsite). Team member can make a change, all other disciplines are responsible and can adjust their parts accordingly

Visualization methods for sustainability:

- Better engineering decisions as a contractor
- Clearer picture for the client
- Design changes without any delay in time or cost increase

Performance Analysis & Evaluation methods for sustainability:

- Merge of Design & Analysis will give optimized building performance
- Better quality of data will produce minimum errors and miscalculations
- Energy modeling is done for reducing energy needs and analyzing renewable energy resources that can contribute to low energy costs
- Building massing is the analyzation of a building form and optimize building envelope
- Sustainable materials can be used to reduce materials needs and use recycled materials
- Site and logistics management will aid in reducing waste and carbon footprint
- Day lighting analysis will minimize energy costs
- Water analysis diminishes water needs in a building
- Economic analysis to forecast the financial impacts

Construction Phase consists of:

- Continuous analysis for possible environmental effects
- Thorough design details of the whole project
- Material take-offs from given sheets

Continuous Analysis methods for sustainability:

- Construction effects on the neighboring environment measuring energy use, pollution, any environmental effect: Propose methods to lower the results

- Design Details, drawing in 3D allows the sections and details to be made easily ready for construction. By reducing construction defects, the ongoing operational costs are minimized and result in a faster, safer construction

Detailed Material Takeoffs methods for sustainability:

- Offsite fabrication eliminates over ordering of any material, reduces waste generated, allows cut off materials to be reused or recycled in the project. Components will fit better together on site as they have been fabricated using a coordinated information model. Fewer deliveries to and less waste generated removal from site

Operation phase consists of:

- Monitoring and recording building lifecycle performance
- Updated alterations and changes to the project
- Seasonal commission and maintenance of the project
- Access to sustainable information
- Monitoring & recording building performance in terms of the following concerns: water / wastewater treatment, energy consumption, carbon emission, better decisions for improvements and changes after the results and reduce resource & waste generation (recycling)

Updated alterations & changes to the project:

- Additions/ adjustments made to project can be easily tracked and documented.
- Traditionally, any alterations would repeatedly need surveys and on site research which cost time and money.
- Seasonal commission and maintenance of the project
- Plan maintenance activities that can be efficiently minimizing cost and disruption of occupants
- Access to sustainable information to all team members

4. DISCUSSION AND CONCLUSION

Building Information Modelling (BIM) has the power to enhance the design of a building, reduce its costs and further save energy. However, very little research has been carried out on its negative impact on relevant sustainable practices. A US survey illustrated that many of the industry professionals do not see sustainability as a necessary primary application, which makes it apparent that more sincere effort is required to encourage the integration of sustainable design and construction into BIM model.

In the AECO industry, BIM is one of the most useful processes that can produce correct planning timetables and also calculate, and ultimately minimize, the costs of a project. Using BIM, a 'virtual' project can be constructed prior to analyze the possibility of a construction project, which aids to create structures that minimize waste generation and optimize energy consumption. Information models generated from multiple sectors and organizations can be incorporated further and features of BIM including the highly specific detailed and realistic images of the to be created structure; a 3D model incorporated with features like cost, energy, and structural analysis; and 4D scheduling (linking of the 3D components with time-related information).

A US study utilized a web-based form to gain the opinions of professionals in the 2009 Design Build Institute of America National Conference. The survey was in context of the use of BIM in recent design, engineering and construction, the perceived importance of sustainable construction and how BIM can be adapted to support future sustainable building projects.

The completed surveys indicated that most of the survey takers were architects, engineers, contractors, consultants or subcontractors working on projects. Half of them were LEED (Leadership in Energy and Environmental Design) accredited. BIM was concluded to be used largely in the architecture engineering and construction industry (89% of company practices), but the majority (65%) have used BIM tools for between one and five years.

The majority of survey takers agreed that their organization considers sustainability essential (63%) and encourage clients to adopt sustainable methods, like sustainable site development of the project, waste water treatment, energy efficiency, the use of sustainable resources, and efficient project management. Of those surveyed, 91% suggested that BIM is the best used to support sustainable building design and construction practices early on in a construction project's design stage. The surveys also suggest that design-build projects (in which the design and construction of a project are contracted by a single organization) and incorporated project delivery methods provide the best sustainable environments to use BIM as a tool for 'green' buildings.

Although contractors, sub-contractors and those engaged directly in design-build projects envisioned saw BIM as an effective tool to aid improve sustainable development , this was unlike the case for architects and survey takers from organizations involved in the conventional method for project delivery with different entities for the design and build construction phases. A total of about 25% of green building projects completed by the respondents' organizations within the last 5 years had been LEED certified. The majority (88%) of those certifications were required by the owner.

Most survey takers also continued to believe that sustainability was not a necessary application of BIM models and raised the problem that various applications of BIM as a process did not always work together quite efficiently. Thus, in order to improve on the sustainability aspect of construction projects, the study concluded that design, engineering and construction professionals would surely benefit from more awareness about the impressive benefits of BIM use and further steps should be taken correctly for information exchange.

5. FURTHER RESEARCH

Further research will basically concentrate on the incorporation of BIM, Sustainable Design Analysis and SBE (Smart Built Environment) technologies for a long-term performance monitoring, by using the aspects of sustainable development as a 'test bed'. Sycamore is not used for structural purposes due to its perishability and susceptibility to rot and insect attack compared with other hardwoods [6]. Sycamore performance monitoring will further include the moisture content level together with temperature levels and relative humidity of the atmosphere in the immediate surroundings. In addition to this, digital micro probe (DmP) will be utilized as a reliable, renewable and non-destructive method for early detection and analysis of wood decay. Performance enhanced monitoring of the earth as a system will include aspects such as humidity, temperature, and VOCs in the terms of air quality, and also air speed and its corresponding pressure. Moreover, additional CFD simulations will be conducted so as to compare the real results with those developed by the computer software simulation. Hempcrete performance monitoring will gradually include temperature and relative humidity aspects, and also certain heat flux sensors to monitor dynamic changes of the relative U-value as it goes through its intermediate periods of wetting and drying.

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