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A Review: Lifecycle Assessment of a Building by Using BIM

Prof. Sahil Salvi[1], Mr. Abhijit Patil[2], Ms. Sejal Mhetre[3], Ms. Yamini Patil[4], Mr. Anand Shinde[5]
[1, 2, 3, 4, 5]*Department of Civil Engineering, Pimpri Chinchwad College of Engineering and Research, Ravet, Pune, Maharashtra, India*

Abstract: ***BIM is the most ruling software from last two decade in construction sector. Building Information Modelling (BIM) is a digital representation of overall building. BIM is a 3 D model process that help us to work efficiently. BIM also help us to reduce the impact on environment. Several research paper, conference paper, articles were analysed based on their research focus. This paper gives a review on, Lifecycle Assessment of a building (LCA) of a building using BIM is discussed. LCA is the method that helps us to known the impact of our building on environment. The finding of these studies will be useful for the engineer, architects and for every construction industry as it will helps us to minimize the impact of our building on environment.***

Keywords: Software and Environment, BIM, Lifecycle Assessment (LCA), Eco-friendly, Computer and Construction, Sustainability, Virtual Design and Construction with Eco-friendly Application.

I. INTRODUCTION

BIM that is Building Information Model is a digital representation of planning, designing of a building. It represents the building's physical and logistic properties. BIM yields advantages in scheduling, designing, implementation and management effectively. Study of BIM uses different software including REVIT, ArchiCAD, Civil 3D, BIM integrated LCA. LCA or Life Cycle Assessment is a technique of assessing the environmental aspects associated with a product over its life cycle. The assessment of a building includes the entire life-cycle of the products and the process involving the use of raw material its manufacturing, transportation, maintenance, reuse, recycle and disposal. LCA methodology is defined in ISO 14040. The guidelines and requirements provided for Life-cycle Assessment are specified in ISO 14044:2006. The integration of BIM into LCA is contemplated to refine the work process and to enhance the planning processes. LCA consists of 3 different work processes involving the conventional process, the semi-automatic working process and the fully automated working process. All the working process include use of tools; the conventional process uses eLCA from REVIT software, the Tally tool is used to calculate LCA in semi-automatic working process and the One Click LCA plug-in tool is used when the models are loaded in ArchiCAD, Revit; in fully-automated working process.

II. LITERATURE REVIEW

Various websites have been searched which provide free access to journals and so as to literature reviews. Many literature reviews were available on BIM. Abstracts of them were giving ideas about what those literature reviews contain. By reading abstracts, out of many, 10 good literature reviews were sorted out which covered almost all the corners of BIM. Selected literature reviews were read thoroughly and neatly. After reading and understanding each section of every literature review, small informative notes regarding each literature review were written separately. Compilation of those notes have been done in this research paper which will be helpful for readers.

1) The BIM revolution: a literature review on rethinking the business of construction [1]

In these literature review they have reviewed need to software for proper execution of the work in construction phase we phase lack of communication, improper management, limited trust, contractual dispute all these end up with the delay in project increase in cost so to overcome these how we can use the BIM in the each and every construction phase. In day to day we are modernizing in each and everything except the construction industry still in most of the places old practice of construction is done .BIM is the key to modernize the construction phase from each point of view .Building Information Modelling/Management (BIM) as a tool to assist in changing the way projects are delivered. We have observed that off-site production of building components has need of more labours which helped to do our work more productive these focus us to the need of data in the construction that focuses completely on the need of data i.e. information .in BIM 'I' Completely focuses on data which helps us to analyse and helps us to understand the current productivity gap. We can say that 'I' is the heart of BIM.

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BIM also help us to manage the every phase of our construction. The whole world currently operates in an 'antipathetic' rather than a 'concerted' culture. The Australia lies 1st in these process. In help in reducing the cost, completion of project in optimum time and manage each and every thing properly without much wastage of the material or without improper use of the labour.
So construction company need to modernize themselves with the upcoming generation so that they can execute their work as soon as possible with proper management with optimum cost and focus must be on quality work rather than quantity work. BIM is the software that help the construction company to achieve the goals .BIM just only not help design but also helps in the management and the application of our drawing. The arrival of this modernization within the construction industry will lead organisations towards a more integrated process .These phenomena can be a digital revolution for the construction industry.

2) *Implementing Life Cycle Sustainability Assessment during design stages in Building Information Modelling: From systematic literature review to a methodological approach* [2]

The author in these paper provide a Systematic Literature Review (SLR) which aims to detect opportunities to integrate the LCSA into the building design process and in Building Information Modelling BIM. Various construction activities like land clearing, operation of diesel engines, demolition, burning, and working with toxic materials contribute to air pollution. Big source of PM 2.5 on construction sites comes from the diesel engine exhausts of diesel generators. After construction also the building harm the environment in various ways so these can reduce the life of building too.
So to reduce the impact of building and construction phase on the environment and to increase the efficiency of our building we need to implement the LCA life cycle assessment. Sustainability is the promotion of conservation of natural resources, preserving the environment. It is the use of recycled material or the renewable energy. There are mainly three pillar of sustainability they are economy, environment and social, so to achieve these pillar Life Cycle Sustainability Assessment is considered as the best option. So BIM is the key to use LCSA in the construction stages of the building. How exactly BIM can be used so that we can achieve our goal to reduce the impact of our building on the environment. Correspondence, standardisation, and ability to exchange information are needed to implement LCSA in BIM.
LCSA helps us to how we can use a resources so that there are positive impact rather than the negative impact on the environment. LCSA helps the owner to choose the sustainable product that will reduce help them to reduce cost as well as to reduce impact on earth's environment. LCSA and BIM must be integrated. The study proposes that there is need to have workflow between LCSA and BIM. These paper focuses on the methodology gaps which need to fulfil. Systematic literature review results show that the adaptation of the three dimensions and the data requirements are main achievements.

3) *Building information modelling (BIM) for sustainable building design* [3]

The main objective of this article was to look into the contributions which building information modelling (BIM) can make to the development of sustainable building designs. As the technology is expanding in every sector it has resulted in worsening of physical environment. Construction industry also contributes towards the emission of greenhouse gases. As per the data received from US Green Building Council in 2009, buildings in the United States absorbs 30 percent of the world's total energy and are responsible for 48 percent of greenhouse gas emissions in the US. So there is need to look into this matter and take the necessary steps for the sustainable design of building in construction industry.
It is presumed that BIM is a very useful component in minimizing industry waste considering wasted energy, adding value to industry products and reducing the impact on environment. Research on the use of the BIM in designing sustainable buildings is rewarding, at the same time it is important to increase awareness amongst the stakeholders, contractors, builders about main capacities of this new technology and its unrealized contribution towards sustainable development. As the importance of BIM has become highly valued, more activities in the construction industry have focused on adopting BIM for sustainable design strategies. A number of published articles on BIM related sustainable design have provided insights into the energy usage analysis alone. Some illustrated how BIM assists in sustainable design of the electrical and mechanical portion of buildings. This paper has provided information about how, the contribution of BIM to sustainable building design is expressed from the two different point of views that is Integrated Project Delivery and Design Optimization.
Building Information Modelling (BIM) is ideally suited to the delivery of information enabling improved design and building performance. Two major useful attributes of BIM in relation to sustainable building design are those of Integrated Project Delivery and Design Optimization. Traditionally CAD-based designs are little bit time-consuming and requires skilled professions. However, with the help of BIM, designers can develop the building design systematically in the very early stages of the construction phase and produce better outcomes.

4) Literature Review of Building Information Modelling (BIM) Intended for the Purpose of Renovation Projects [4]

Scope and terms of BIM in the field of renovation are included in this paper. Some gaps to be filled with future works are also mentioned. Today, the renovation sector is vast, diversified and very active in the whole world. Still, 3D digital mock up is exceptionally available for the already present structures as it is fairly new technology. Various scanning and 3D laser mapping techniques are used for creating 'as-built' models of such structures. This is challenging to manage and feasible with major investment only. So it tends to lack competitors. But in the field of automation installation and maintenance, supply chain and maintenance, space sharing optimization and the workers' safety, it can be proved that the BIM is a step ahead of all. There is a need to make BIM as the fastest and accurate method for the renovation industry too. For this, BIM has to adopt the real conditions, should have to fill gaps and overcome some non-technical issues. Not only BIM, Industry should also accept BIM for bit by bit evolution. As BIM is a newer technology, questions like "What will be the exact proportion of work that needs digitalization?", "What will be the exact cost for the project? "Which method should be used to create an 'as-built' model?" are unanswered. This literature review talks about 14 maturity tools which can be the solutions to renovation sector problems faced by the current market situation. At last, this review concludes that the converting renovation sector to BIM has a lack of data and information. But change practices and modifications can make BIM more efficient in this sector too.

5) Analysis of Building Information Modelling and scope of BIM in India [5]

BIM is the catalyst for the countries to boost up there construction sector. BIM digitalize the building and provide us the solution at each construction phase of our construction. BIM increases the quality of our project and also it help us to carry out different task such as maintenance .in the normal construction there is lack of communication between the client and project members v but in the BIM there is Platform called BIM 360 which can be accessed by the client. In BIM360 various engineering models are drawn and uploaded so these will increase the communication between client and project members. These also helps the project members to coordinate with themselves that which work is completed which is going on. BIM also help the client to analyse the rate and work completed. The main feature in the BIM is the clash detection. It helps to check the clash between mechanical and structural modelling. This saves time, labour, money. In BIM efficient energy analyse is done which is the advantage and important advantage. BIM has different uses such as it help to estimate cost at faster rate. BIM help to estimate the quantity of material needed, it's rate And cost formulation.in India it is urgent to use BIM like software to tackle the delayed work and for easy detection .there is need to invest for initial cost for BIM and to train the people. The developed countries have already taken BIM in there construction sector at very high rate for eg. USA or UK but adoption rate of BIM in India or in developing countries is low. A collaborative effort is needed in India and other developing countries from government and private sector to increase the usage of BIM.

6) Life-Cycle Assessment and the Environmental Impact of Buildings: A Review [6]

The detailed introduction about Life Cycle Assessment, the methodology for caring out LCA and the need of LCA in buildings is studied. Life Cycle Assessment is a methodology for evaluating the impact of various processes and materials on environment. The assessment includes the entire life-cycle of a Product, process, or system including the extraction and processing of raw materials; manufacturing, transportation and distribution; use, reuse, maintenance, recycling and final disposal. The need to study LCA in building sector is not only due to the its complexity in design but there are also some other factors that include 1) longer life time of buildings, 2) during its life span the building may undergo many changes in its form and function, which can be as significant, or even more significant, than the original product, 3) many of the environmental related issues of a building occur during its use, etc.
Life cycle assessment is mainly defined in four phases that is Goal and Scope definition, Inventory analysis, Impact assessment and Interpretation:

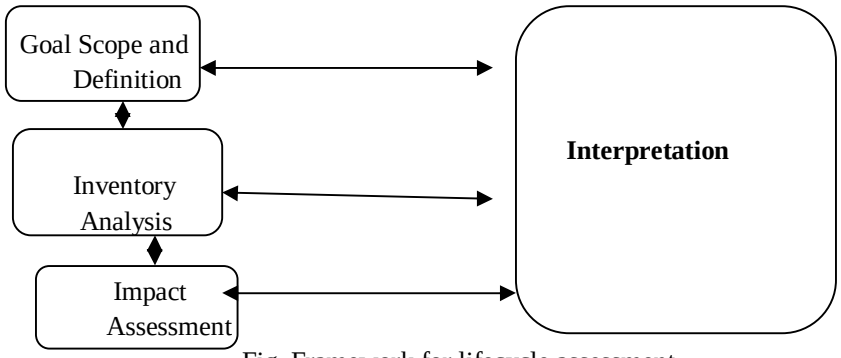


Fig. Framework for lifecycle assessment

a) *Goal and Scope Definition:* The goal and scope definition defines the direction of the study and the benchmarks, with which the study will later be appraised in the interpretation stage. According to ISO 14040, the goal of any LCA states the required application to carry out the study, the reasons for carrying out the LCA study and the intended purpose. Within the goal and scope definition, the description should include all details starting with: the function and the geographical location of the building, and other technical features. The system boundaries should be clearly set, whether the study will consider the whole building life-cycle, or one phase of it; the whole building, or one system; and the environmental impact categories to be studied should be determined.

b) *Inventory Analysis:* The Inventory Analysis is the second step of LCA and it includes collection of the data and all calculation procedures. This is the key step as all data collected is the base for carrying out the further study. The life-cycle inventory phase (LCI) generally uses databases of building materials and component combinations. The quality of life-cycle assessment is directly related to the quality of inventory data and its correctness.

c) *Impact Assessment:* The main aim of impact assessment is to examine the product system from an environmental point of view using impact categories and category indicators connected with the LCI results. The framework for impact assessment starts by selecting the environmental impact related categories of building like global warming, acidification, toxicity, etc. followed by a classification step, which assigns LCI results to the impact categories.

d) *Interpretation:* The final step of LCA is interpretation the main purpose of this is to analyse results, reach conclusions, discuss limitations and provide recommendations based on the findings of the preceding phases of the LCA study and to report all the results in a transparent manner.

7) A Review: Application of Building Information Modelling (BIM) over Building Life Cycles [7]

These review tells the use of BIM throughout the project life cycle. It was seen that the implementation of BIM in the industrial sector is premature but BIM is receiving rapid attention. The most important technical aspect of the BIM software is that it enables data management and 3D modelling .BIM should be linked and not treated as separate software. BIM is capable of reducing material waste, resource wastage and cost control during construction process. BIM is the key to achieve a sustainable building. The major problems in the implementation of BIM are the resources needed for the implementation and the training cost. BIM gives a digital model in the virtual environment .model in BIM gives complete and accurate data and accurate dimensions that are required for design purpose. BIM give access to all professionals to work together professionally and correctly than using old fashioned processes. BIM helps to increase the coordination with the project members. As BIM adoption rate increases, teamwork among team members increases thereby leading to reduction in project cost, time saving, customer satisfaction and improved performance. BIM presents a new concept that enhances collaboration between stakeholders of a project. This collaboration helps to enhance the efficiency and increase unity among the stakeholders who seen as a rivals most of time. the general statement from professionals within the AEC industry suggest the emergence of BIM as the most recognized performance analysis tool in building concept, planning, and design. These review suggest the implementation of BIM as is more advantageous than normal method as it overcome the some of the important disadvantage such as lack of expertise within project team etc. The future of BIM is bright and stimulating.

8) A review of Building Information Modelling for construction in developing countries [8]

The literature review has presented the overall research of BIM in developing countries. In the developing countries there was no research or any interest was seen in BIM before 2013. Expect the countries like India, Malaysia. Nearly 64% of articles was published in Last two year which overall shows the importance of the BIM increasing in the developing countries. The developing countries are adapting the BIM faster. BIM in developing countries was adopted in industry, organizational, and individual levels. BIM is the tool to promote contractor competitiveness. BIM at organizational level is low, at individual level it is also low because there are many barrier that are to be tackled. The compatibility and the integration between the BIM and the currently used software should be increased as a result BIM would work more efficiently. There is less use of BIM in the infrastructure and the facilities project in the developing countries due to the barrier so it conclude that more work should be done on the BIM and the barrier must be reduced .in conceptual studies from India and Malaysia debate the BIM , GIS and TLS should be integrated. The small construction organisation in the developing countries should ask government to give financial and technical support for the BIM implementation. The energy saving carbon reduction in the early stages of the construction is the area of BIM research.

So BIM is the way to increase the speed of the construction industry and help to contribute more in lesser time and in optimum cost to speed up the developing countries development.

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9) BIM-Based Life Cycle Assessment of Buildings—an Investigation of Industry Practice and Needs [9]

The insight industry practices of BIM-LCA is been provided in these paper. The company in the construction sector uses the quantity take off approach for the implementation of the BIM - LCA .some of the studies focuses on BIM–LCA, as these studies not through the industrial perspective, where information is relevant for practical implementation in industry. The paper investigated the research gap by examining industry practices and needs in BIM–LCA. The gaps are specific challenges related to the design of the models, and feedback on a prototype.

The Five approaches to integration of BIM–LCA, as defined by Wastiels are

a) Enriched BIM
b) Quantity take off
c) Import of geometry
d) Intermediate viewer
e) LCA plugin

The most important work in the BIM-LCA is the data exchange. For BIM–LCA it is important to consider if the standard structure can contain the data you want to extract and exchange. In BIM-LCA it is necessary to exchange data in each and every part of the construction. Due to different Level of Development of models during a building project, the prototype uses predefined components. The different companies consider different aspects important in BIM–LCA, including visual interface, transparency of data, automation, flexibility of data sources, and easy access to evaluation of design solutions. Most of the company considered the 3D view in the prototype valuable for transparency and communication. Also some the company arises whether it's effective as discussed by the writer.

The original model uses open and neutral file formats such as IFC and OBJ for the data exchange. Every company will have different need resources and goals so the BIM-LCA should be different need to relationship the workflow. Smaller company will surely beneficial by the prototype. There are also some degree of inaccuracies in the LCA that should expected in the early stages of the building.so there must be different workflow but should provide clear transparency of result and the clear data description.

10) Quality Assurance and Quality Control for Project Effectiveness in Construction and Management [10]

The development industry has been scuffling with quality issues for several years, and therefore the cost to our economy is dramatic. The price could potentially be reduced significantly if the industry were to embrace the concept of quality assurance that has been used with great success by many other sectors of the economy. Building owners also have to be compelled to be educated on what's quality assurance so they'll begin using their voice to encourage adaptation of this approach to guard their investments and reduce the price of construction. Internal control (QC) and Quality Assurance (QA) represent increasingly important concerns for project managers. Defects or failures in constructed facilities may result in very large costs. Even with minor defects, re-construction is also required and facility operations impaired. Increased costs and delays are the result.

Quality Assurance and internal control is an important a part of any construction process to boost the standard and uniformity of the project. The requirement for QA and QC in construction projects has increased considerably in recent times because of significant changes, advancements in technology and high expectation of the users. The QA and QC maintain uniformity in construction process and ensure more economical utilization of materials leading to significant reduction in cost to the users. The extra cost involved in QA and QC is directly proportional to the advantages.

A technique has been developed for QA and QC in housing industry. The methodology accomplishes the required quality in construction process. Ultimately the presence of quality is vital. So generally we are able to define the standard in several ways as follows, Quality is conformance to requirements or specifications. Quality is fitness to be used. Quality is that the degree to which a collection of inherent characteristics fulfils requirements.

11) Research on the Integration of BIM Technology in Prefabricated Buildings [11]

Study of the application of BIM in prefabricated structures is done in this literature review. This paper also compiles information of various BIM software's. Prefabricated buildings are in the limelight as traditional building technology seems harmful to the environment. Brief overviews of prefabricated buildings and BIM technology are included in this literature review. Revit, PKPM-BIM, 3DS Max/Laminin, Navisworks, Tekla structures, Microsoft project are some of the BIM software's Those software's are used in various stages of prefabricated structures like design stage, construction stage, operation and maintenance stage. Different stages demand different applications.

In the design stage of prefabricated building, there is a need for fine and constant quality modelling, 3D visual design, collision check and plan optimization. Whereas in the construction stage, clarified management of construction site layout, simulation of construction schedule and virtual animation display are needed.

All the application of BIM in various stages of building are briefly explained in this literature review and it concludes that the BIM technology applications to prefabricated buildings is overall a good idea.

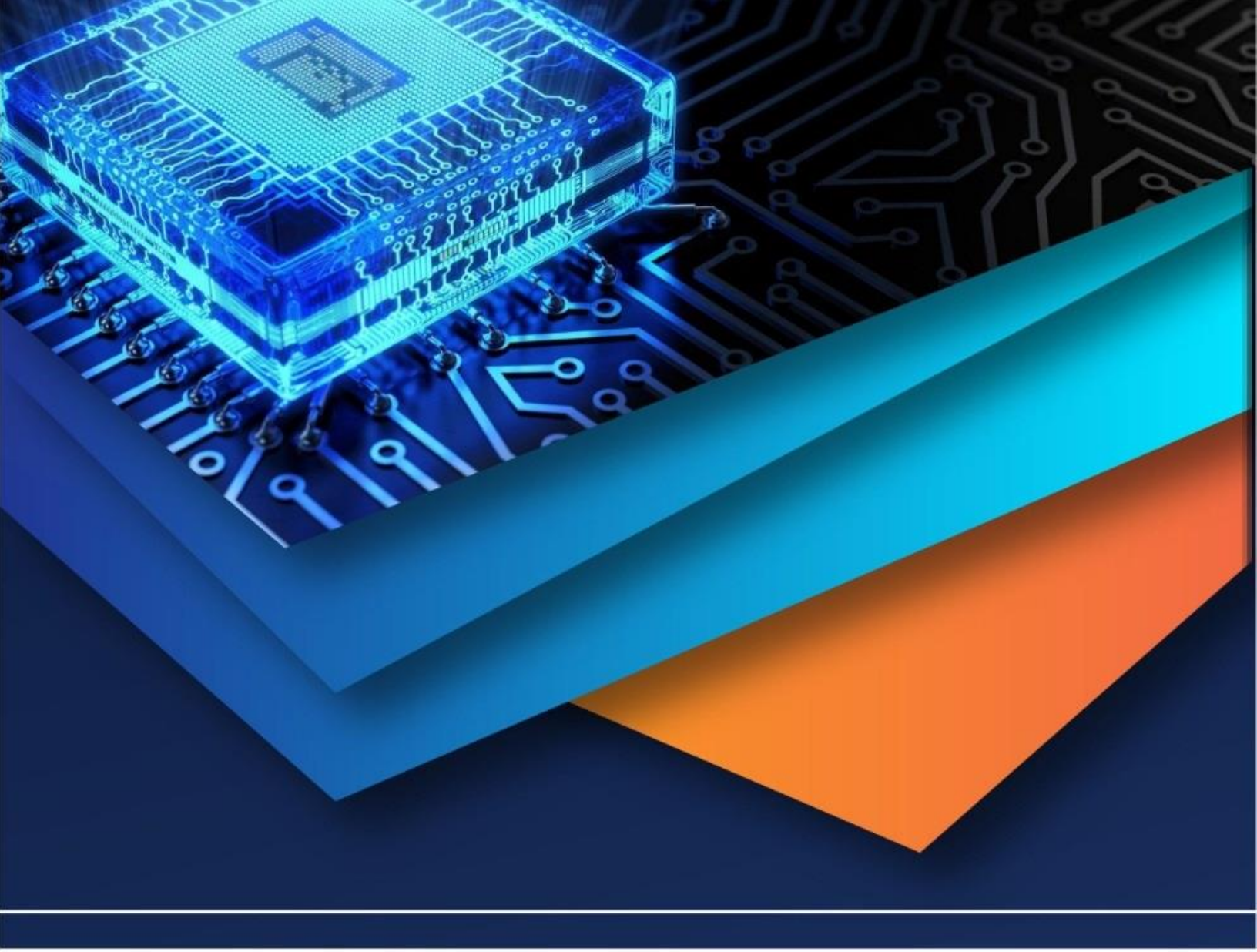
III. CONCLUSION

As the construction industry is a major contributor of greenhouse gases, carbon emissions there is a need to hold the whole Life Cycle Assessment of building so as to have a sustainable development of a building which will ultimately result in conservation of natural resources, preserving the environment. Life Cycle Assessment is a process of evaluating the consequences of a various processes or materials on environment. LCA is generally carried out in four stages that is goal and scope definition, inventory analysis, impact assessment and interpretation. The ISO 14040 address quantitative assessment methods for the assessment of the environmental aspects of a product or service in its entire life cycle stages. So to carry out LCA on building BIM would be the best option as it creates a digitalized model of a building and helps estimate the cost at faster rate, estimate the quantity of material needed & it's rate and provide the detailed insights about the energy efficiency of a building. Therefore all the construction companies need to develop themselves with upcoming technologies like BIM to deliver their projects with proper management with optimum cost and quality work. BIM involves handling of various software's like Autodesk Revit, StaadPro, Navisworks, ArchiCad, Sketch Up, etc.

BIM is used in each and every phase of construction phase. It helps design, analyse, and gives accurate and complete data and accurate dimension of a building. BIM increases the coordination between the client and the project member. It gives information of completion of each stages in construction to client and project members. BIM also increase the bond between the stakeholders. Some of the main feature of BIM are clash detection, energy analysis, cost efficiency, safety analysis and check on the progress of work, quantity surveying and quantity management. The main barrier for implementation of the BIM is the initial cost and the requirement of trained person. So to overcome these barrier there must be some financial support from government to the industry. Based on all the literature reviews referred it can be concluded that BIM is the catalyst for the countries to boost up there construction sector as it creates as it digitalize the building and provide the solution at every stage of construction.

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