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A systematic study of building information modeling and its associated concepts.

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ABSTRACT

Construction projects involve integration of various factors. The complex process and several aspects associated with the building construction increase the demand for proper management. Building Information Modelling (BIM), comes as an aid and helps to control the technical and non-technical elements involved in the building construction process. It helps to design the features of the building, plan energy effective mechanisms, making the building resilient to all sorts of natural disasters. Considering the efficiency of BIM, civil engineers started using this at the pre-construction, designing, planning stages and in most cases it is used to control the entire life cycle of the project. BIM are used to design the entire process for large scale process while in case of small scale projects, it is only used to design a single or a couple of components. This study analyzes the research aspects related to BIM during 2010 -2021 and consolidate the broad research field under four categories to bet better insights.

Keywords: *Building Information Modelling, Energy-Effective Mechanisms*

1. INTRODUCTION

The technological advancements have brought huge modifications in the process taking place in the construction sector. The methods, techniques and the strategies deployed in this sector have been significantly transformed to meet the market demands. Augmented reality (AR) and Virtual reality (VR) contributed more for the advancements taking place in the construction management sector [1]. The natural changes taking place in the Earth has forced us to develop eco-friendly, sustainable technologies. Buildings which serve as a basic need for humans are no exception to this transformation. In such case, the sustainable features for a building is designed and sent for approval at the preconstruction stage itself [2]. Natural hazards are the first and foremost concern for the civil engineers while developing a building plan. Hazard identification is a tedious process since various criteria's have to be considered while planning. 2D drawings are found to be used mostly during the process of safety planning with respect to the construction process. Subsequently the engineers convert the 2D diagrams into 3D models with the help of software and execution sequence is planned [3]. Spatial technology has become a powerful tool for identification of remote objects. The high resolution of images facilitates easy identification of objects and helps us to get better understanding about the features of the terrain. Recently object detection based on satellite images has been predominantly used for the purpose of monitoring the progress of the construction and related site information. 4D Building information models are developed to create automatic labels for the captured images [4]. Researchers have integrated the spatial information, temporal information which are site specific in general and tested safety planning process [5]. Additional consideration factors have made the construction process complex and require processing large quantity information. Building Information Model is "a data management platform that has a rich set of spatial features and building attributes" [12]. Building Information Modelling (BIM), is found to be helpful in managing the construction projects and to develop geometric modelling. It is found to be effective and beneficial for reducing the cost of the project and helps in controlling the project cycle. Considering the advantages of BIM, engineers mostly use this for large scale projects. In case of small scale projects, BIM is used for individual components of the projects rather than the entire project [6]. BIM management consist of online system that facilitate indexing, storage, and querying and web visualization of elements present in the BIM. Uploading, sharing and commenting on BIM, can be done with the help of Online sharing and collaboration [7]. Cloud computing is the most recent integration in the construction industry. It also enhances the safety and security of the information which is shared in the common platform. It also helps in multi organizational collaboration and integration of IT in the project [8]. Information and Communication Technology (ICT), has developed many tools to support the management industries by helping in architecture, engineering and construction purpose. ICT is associated with BIM and serve its purpose of designing, managing construction projects and it is found to be effective in general [10]. So far the technical part and effectiveness of BIM is discussed. BIM includes both technical and non technical part. Most researchers who study BIM focus only on the technical part

considering BIM as a software suite. The non technical part of BIM includes management practices which are often found to be associated with relationship with the stakeholders [11]. During preconstruction stages, the integration of BIM, geospatial analysis is found to yield substantial benefits. BIM is found to provide spatial relationship, geometry which can be analysed, visualised using GIS [12]. BIM helps in schedule management process during construction by assisting and informing the in charges about the project requirements such as raw materials, equipments, and fund requirements [15]. BIM users find it challenging to extract the construction specific instruction from the software. Sometimes the information in the software are prone to errors and are inefficient in nature [17]. BIM is used to increase the sustainability of the buildings. Sustainability mainly deals with the environmental, economic and social aspects of the project [20]. As one of the recent use, BIM is used to evaluate the energy performance of the house by virtually modelling it [21]. Thus BIM is predominantly used by the civil engineers for various stages of the building construction process. It is also found that BIM is used along with GIS for both large scale and small scale projects. This paper briefly explains the applications of BIM in the project cycle and postulates the results obtained by various researchers to get better understanding regarding the efficiency of BIM.

2. LITERATURE REVIEW

Braun et al has developed methods to label images automatically based on the inverse photogrammetry and 4D Building Information Models. In this case the automatic labelling is done with the help of BIM which provides the semantic information about the building. The image based neural network can be trained based on the labelled data. Subsequently, the labels can be developed for classification which is a basic task and for semantic segmentation which is complex in nature. They even applied the labelling procedure to various construction sites of the real world and automatically labelled approximately 30,000 elements. The pixel based area comparison with the manual labels has been made to validate the correctness of the labels which are automatically assigned to the images in this method. Bryde et al in 2013 decided to study the utmost extend of benefits rendered by BIM in the construction projects. For their research they collected secondary data from the construction projects which used BIM in their work and the number of projects covered by them was 35. The extend of benefit is understood and validated based on a set of project success criteria and by analyzing the content collected which are related to the considered project. The positive benefits reported by them includes significant cost reduction, the project life cycle control and time savings. The negative impacts include technical errors reported in the BIM software which deviate the accuracy of the obtained results. They also reported that the challenges in using BIM can be overcome by creating awareness about the existing issues and conducting more training sessions. It is important to understand and have knowledge regarding the BIM since it is involved in design, construction and maintenance of buildings. BIM is deployed in the construction projects of various range from small scale to large scale for the purpose of cost reduction and error free calculation. In order to design a construction project, it is important to collect sit information and surrounding details. It involves various features such as buildings, trees, roads, signals, and other types of natural and manmade features. The collection of these data is called as ground data collection and it is a tedious process when done manually. Furthermore it is time consuming and requires more workforces. In order to conserve time and reduce effort satellite images are being used to collect data about the building and its associated features. Similar to automatic labelling, recently automatic building footprint extraction from high resolution satellite image has been developed to enhance the preplanning process in construction. In order to improve the building extraction accuracy, Deep learning based semantic segmentation has been studied by the researchers. Geographic Information System (GIS) maps, datasets have been rarely used to extract building information. Li et al, in their research tried to extract information from GIS datasets. They particularly integrated GIS map datasets with WorldView-3 satellite datasets. They did their study at 4 cities including Las Vegas, Paris, Khartoum and Shanghai. Data augmentation, post-processing, integration of GIS map data with satellite images has been combined with U-Net based semantic segmentation model. The entire life span of the building is covered by BIM, particularly from its planning to demolition. It is to be noted that site is important for each and every construction. The requirements for the site and the buildings to be built, the territorial planning documents are essential [22]. There are various differences regarding the buildings, structures with respect to its age, usage, ownership and so on. These inherent differences affect the BIM applications in maintenance, deconstruction processes. New buildings are easily adapt BIM while the older ones couldn't integrate it due to the challenges such as high modelling required to convert the captured data to BIM objects, BIM information update, uncertain data in the buildings [23]. Advanced portrayal of compositional and ecological elements is given by BIM and Geographical Information Systems (GIS). GIS centre on the full scale level structure portrayals while BIM centres on the miniature level portrayal of structures. To examine BIM-GIS joining in reasonable assembled climate, Wang et al studied the case with respect to technologies for data integration, applications, urban governance and building energy management. Architecture, engineering and construction (AEC) processes and information should be studied to get better understanding [24]. BIM includes 3D building representations and spaces which are embedded in it. Even though 3D data is collected in large amount with high resolution, problems such as information existence in traditional methods, improper mining, irregular spatial expression still exists [27]. Data exchange between BIM and GIS includes transformation from IFC format to shape files. Zhu et al proposed an Open Source Approach (OSA) which involves derivation of geometric information through spatial structure. It is found that OSA is efficient than DIA. BIM and GIS can be linked with OSA in a stable and efficient way [28]. Construction projects are found to be prone to various risks. Natural hazards such as earthquakes, landslides, floods are estimated to cause greater damages to the buildings than manmade problems. Research shows that BIM is a systematic risk management tool used to support project development process. In addition to this BIM can serve as platform for core data generator. In real environments, BIM based risk management is not used. Zou et al suggested that future research should include a multi-disciplinary system thinking, investigation of methods , processes related to implementation, development of new technologies to manage traditional risk and finally the developmental process should be supported [29]. Construction project risk management involves various approaches of which Case-based reasoning (CBR) is one of the important methods. The knowledge gained in previous accidents and risks should be recorded and maintained which could be retrieved at the required time. For retrieving these stored data, Natural Language Processing (NLP) can be used. Python programming language is used for developing a

prototype system. Preliminary tests show that this model is capable of retrieving and projecting similar cases [30].

3. METHODOLOGY

This study aims to analyze the recent advancements in BIM. This research tries to do a holistic study in the factors associated with the BIM. For this purpose, papers dealing with the BIM and associated technologies particularly GIS is taken for consideration in this research. Research papers published during 2010 – 2020 were taken for this study. During this course of time various technologies has been found to be integrated with BIM to yield better results. BIM itself is integrated in the preplanning, designing and post planning phase of construction processes. The concept of sustainability also emerged with the recent changes in the environmental conditions and climatic changes. Therefore, BIM is used to do sustainable designing of the building with sole purpose of solving energy consumption issues. To solve this BIM models are used to give better results and helps in energy conservation processes. In case of GIS, images are used toidentify objects present at the proximity of the buildings which are being studied. So BIM study including GIS, energy conservation and sustainable development is pertinent at this present scenario. In this study, the compiling of researches related to BIM is analyzed and it is segregated into four categories. This categorization has been made by taking into consideration the predominantly researched areas associated with BIM. The insights from this study may serve as a compilation of information which can be used as a reference for the civil engineers or planners to understand the recent advancements and predominantly used processes in the BIM domain. So this repository of information can act as an aid for researchers at the time of need. Therefore, crucial analysis, research findings and future suggestions are given in this research to understand completely about the field of BIM.

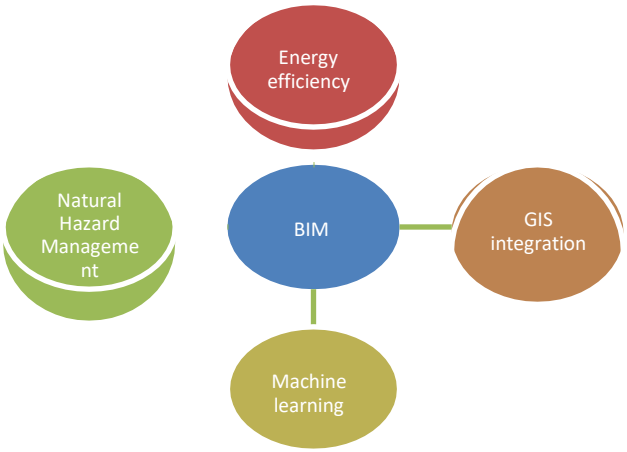

Fig1. BIM and associated concepts

3.1 Building Information Models

Information related to the buildings includes spatial and non-spatial data. Geometry of the building is regarded as non spatial data while the spatial relationship between various components such as the location of the building, number of floors, building space comes under spatial data. Clementini and Felice stated that "Spatial relationship falls into one of the following three basic categories of which the first is topological relationships which describe whether or not two objects intersect, and in the former case, how they intersect. The second is orientation relationships which describe object location with respect to a reference and the third is distance relationships describing the distance of an object with respect to the reference". The Geometric and semantic contrasts existing between the BIM and GIS models confine the full use of GIS based devices to coordinate BIM. Construction and interpretation of BIM can be achieved by IFC which is capable of providing a standardized structure. The generic support to the BIM model can be increased by Query-based approaches. Architecture, Engineering and Construction (AEC) area utilizes spatial ideas and dialects created in the GIS people group to remove fractional models for the improvement of 3D spatial question language [17].

and constructed the entire building virtually with the help of simulation even before the construction work started in the real site. The absolute energy interest for a structure is influenced by the warming and cooling components, shape, direction, proportion between the outside building surface and the structure volume. The tilt will help to increase the efficiency of solar panel performance [21].

Sustainable Built Environment

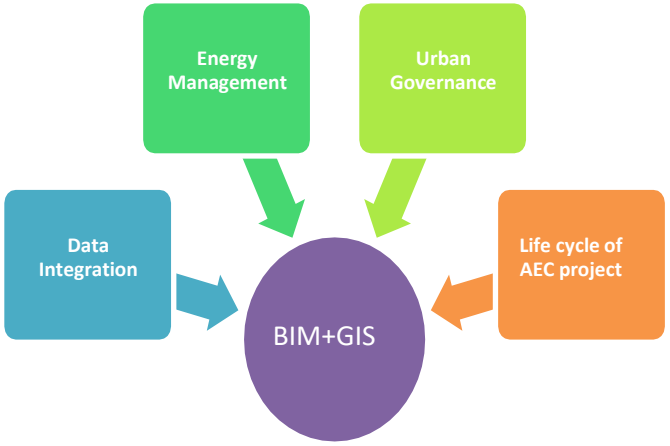

Fig2. Components of BIM

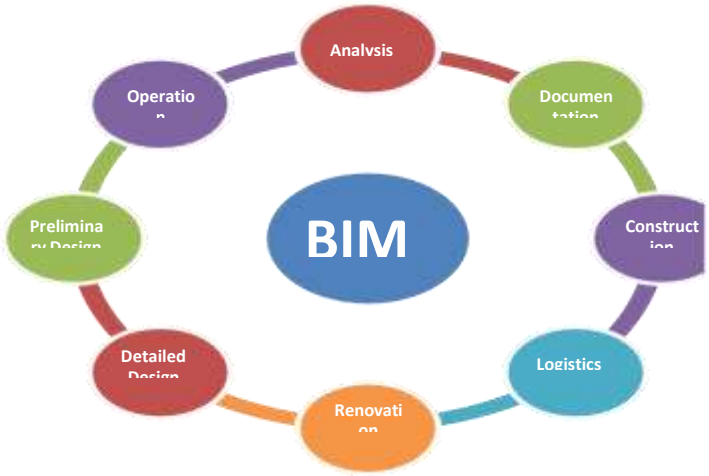

Fig3. Energy efficiency for BIM

3.3 Integration of BIM and GIS using semantic web Technology

BIM and energy efficiency

The alternations offered by BIM in the field of Architecture, Engineering and construction provides energy efficient technologies which can be integrated and managed throughout the lifecycle of the construction project. Froese et al, 2010 applied the BIM model to the building National, institutional boundaries use semantic web technology by integrating large scale BIM and GIS data. For volumetric calculations, the digital model of the construction site is being used. Digital elevation models called as DEM's can be obtained from remotely sensed data such as satellite images and by terrestrial methods including ground survey. GIS analysis is used to develop a geo-referenced model in order to retrieve the height information about the

topography of the construction site [22].

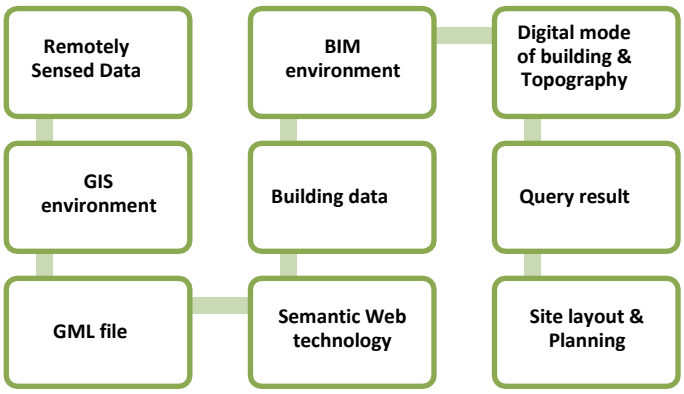

Fig4.Preconstruction plan using Semantic Web technology.

3.4 BIM and Machine learning

The BIM is used to manage the entire processes taking place in the construction project. The manual maintenance and recording of construction process may subjected to some errors such as improper stocking of raw materials, errors in cost calculation, ineffective work flow and so on. In order to channelize the entire process, BIM is deployed in the building process to render effective management. This is found to be reliable, affordable, time saving and reduce the effort of manual calculations which may include errors due to miscalculations [4]

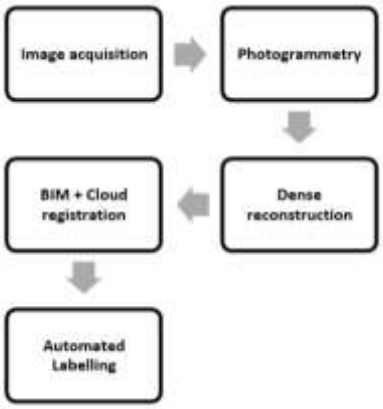

Fig5. Automated Labelling Process

3.5 BIMand Natural hazard management

The occurrence of natural hazards such as floods, landslides, earthquakes has been increased in the present decade with respect to the climatic changes which has close association with these natural hazards. The damage due to manmade features during these hazards are found to be more than the destruction caused by the natural features.

Buildings are the first to be affected by all sorts of natural hazards. So during the planning process, it is essential to design a buildings to be resistant to these type of hazards. To make effective planning AEC professionals use BIM models [24].

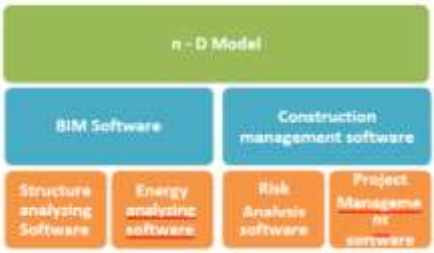

Fig6. Natural risk Modelling using BIM

4. RESULTS AND DISCUSSION

The fast improvement of BIM offers numerous chances to uphold different parts of plan and development. While the extravagance of plan data offered by it serves good quality structures, capacity providence in order to separate development explicit data out of BIM is basic to help development also, other downstream cycles. Development experts today have an expanding need for rapidly and effectively determining data out of a BIM, conveyed such that lives up to their desires. In an exertion to address these inadequacies, this paper created components for questioning development explicit spatial data from a BIM. The required data can be recognized properly with the help of inquiry components. The multiple point of view can be helps in dynamic interaction. For this purpose, method based on inquiry can be used. The spatial thinking about the highlights of a structure is a confounded examination exertion, especially the thinking about the consistency of highlights from one story to another and investigating a plan for subjective topological examination. The utilization of spatial gathering could offer assistance for the spatial assessment of features, and along these lines, outfit BIM customers with an improved game plan of the spatial spread of parts and their assortment. The adjustments in outer orinterior configuration of a construction can affect the yearly and life-cycle financial plan of the structure. Multi component energy appraisal can enhance the plan boundaries also, energy connections between the buildings. Stand-alone structures have the most noteworthy energy financial plan among all the organization blends because of no concealing and reflection. The change of IFC to shapefile can be accomplished with opensource innovation and is more steady and productive than that of the DIA and is practically identical to FME. The resultant shapefile can be utilized in more applications and is simpler to manage. The change is at present unidirectional from IFC to shapefile regarding calculation; nonetheless, it is hypothetically conceivable to play out the converse change with extra semantic data. Shapefile is a configuration that can't be ignored in BIM/GIS mix, as it is the most- utilized trade information design in the GIS business to upholds 3D calculation and can be traded effectively with other non-GIS 3D programming bundles like Collaborative Design Activity (COLLADA) furthermore, SketchUp. The idea for robotizing the naming interaction of building site pictures depends on melding data accessible from the photogrammetric cycle (pictures and relative situation of the camera) and the data accessible from the 4D BIM (object type, objectposition). Since the BIM and the subsequent point cloud are adjusted, an advanced component can be projected onto the picture, at first taken for the photogrammetric cycle. Likewise, coordinating the point cloud and the BIM permits to ensure that lone pictures are thought about where the components viable exist in reality. From the projected BIM components, it is conceivable to naturally associate the covered picture fragments with the semantic data given by the Building Information Model. Since the presented asplanned versus as-assembled correlation additionally offers important data on the presence, everything being equal, the marks can be additionally refined with respect to potential impediments. As a substantial name should just be applied to an in any event mostly noticeable component, the accumulated information from the already applied as- arranged versus as-constructed examination makes this mechanized methodology much more exact. Since the correlations' subsequent components are worked at the right positions, the marks are additionally right. On the disadvantage, just components that were worked as-arranged can be named. The usage of BIM advancement adds to improvement plan the

board. With the improvement of science and advancement and information age, a consistently expanding number of new progressions can be introduced in the improvement plan the leading body of the assignment. For instance, the 3D examining and printing innovation can accomplish the structure segments of replication and rebuilding, applying the energy - saving natural insurance materials to development. The utilization of all out station can encourage the development of pre-development estimation, yet in addition to aid the development of arrange location; augmented reality innovation (VR) to accomplish the BIM innovation can be accomplished in the Visualization and submersion experience. The use of radio recurrence distinguishing proof (RFID) innovation in development activities can encourage the administration of material passage, development plan control and activity and support the executives; the acknowledgment of flying photography innovation can encourage the development of the preliminary phase of designing estimation, development progress in the advancement of the assessment and position of solid support before the audit. In the development business, BIM innovation and cutting edge innovation items with the assistance of the structure in the beginning phases of the undertaking can be intended to communicate the ideal shape and utilization of structures in the development of expert crash maintain a strategic distance from the issue and pointless plan changes, in the Construction activity and upkeep stage to meet the administration of the efficient activity and support staff furthermore, the utilization of canny activity. BIM has a probably use at all periods of the errand life-cycle, it will in general be used by the owner to fathom project needs, by the design gathering to analyze, plan and develop the endeavour, by the specialist for recruit to manage the advancement of the undertaking and by the workplace chairman during movement and decommissioningstages.

5. CONCLUSION

This research has discussed various methods and cofactors associated with BIM and gave detailed information regarding the uses of BIM at various stages of construction process. The integration of GIS with BIM helps to reduce the manual work and give effective results. The spatial data, images can be used to identify the objects at the building proximity and various properties associated with it can be studied by processing the data.

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