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Implementation of BIM to Improve Organizational Capabilities

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***Abstract*---**This paper describes a process that an organization can use to develop its organizational capabilities through the use of Building Information Model (BIM). The process involves identifying and tapping the skills of its employees to deliver lean and green projects. This paper aims to identify the various capabilities necessary to effectively implement Building Information Modeling (BIM) in the construction industry. The study was conducted through a mixed-method approach. It revealed that adopting a BIM adoption culture is necessary for an organization to achieve desired project outcomes. Through a study, the authors of the proposed framework stated that adopting a BIM-based approach can help organizations improve their project outcomes and reduce their carbon footprint. They also noted that it can help them focus on the human factors within their organizations. This paper explores the importance of the social and

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technical skills of an employee in developing an organization's capabilities to achieve green and lean results.

***Keywords*---**Building Information Modelling (BIM), organizational capabilities, AEC sector; BIM capabilities.

Introduction

Firms need to adapt environmental change to remain successful. When the environment is dynamic or unpredictable, firms are especially challenged to revise their routines and plan of action [1]. The learning capability of participant organisations of collaborative projects is embedded in the routines of exploratory, transformative and exploitative learning. The learning capability is positively associated with project performance [2]. Openness is important to develop and share new ideas and encourage other individuals to share their ideas. Knowledge transfer and integration requires effective communication and knowledge sharing within the organization [1]. Firms increasingly operate in a dynamic environment. To stay competitive in such an environment firms have to develop organizational capabilities that enable them to deal with core organizational problems [3]. The concept of organizational capabilities understands organizational change as a continuous and open-ended process of organizational development. To understand different innovation dynamics within firms, micro-economic research needs to focus on organizational aspects of innovation activities; innovation has to be studied as an organized process [3]. The basic and primary inputs into organizational processes were the individual resources of the firm like financial capital, physical equipment, intellectual property, reputation, human resources, etc. In most cases, the resources are not as productive on their own [4]. In this sense, capabilities are only considered the basic inputs equivalent to the specific resources or parts of overall resources. The organising approach explains firm-level conditions in which an effective exploitation of resources and capabilities is implemented [4]. An organizational capability is a high level routine or collection of routines that, together with its implementing enriches ability of an organization to produce outputs of a significant type and quality. They represent a better way of deploying, allocating and coordinating resources [5]. These learning routines help participant organisations to improve operational routines of collaborative projects, such as contractual and relationship management, thereby achieving better project performance. Collaborative projects provide an illustrative context for participant organisations to build trust, develop cooperative relationships and share knowledge [2]. Coordinated organizational practices acquisition induces a better performance, the organizational capability approach implements an organizational diagnosis only based on how entities acquire what organization considers as relevant knowledge and how they share it at different levels [6]. For this India must establish centers which would work on promoting BIM on a large scale plus it must bring in action its worldwide recognized Information and Communication Technology (ICT) leadership to reinforce the large scale implementation of BIM. Hesitancy to adopt new technology, lack of BIM experts, heavy initial cost, lack of initiative and involvement from government are some of the factors which averts the AEC industry in India from enjoying the immense benefits which can be incurred by implementation of BIM [7]. BIM is a new and

promising approach in India which is gradually gaining acceptance by the owners, architects and engineers. The conducted survey explores the power of BIM when used in the field to better communicate and integrate construction information across different trades allowing for efficient work processes and better decisions [8]. BIM fulfills its purpose through all the stages of the construction project delivering benefits in terms of improved design quality, easiness to implement, information sharing ability, reduction of construction costs and design errors, faster work and shortening the construction time, enhancing energy efficiency, supporting construction and project management, and enabling its owners more operational efficiency in the building lifecycle [9]. Building Information Modeling (BIM) is turning into an extensive collective process in the development business. BIM can be characterized as a solid, advanced, three dimensional, virtual portrayal of the venture to be worked for use in outline basic leadership concentrating on creation, correspondence and examination of building data models [10]. Traditional project approaches often face a lot of challenges due to cost and schedule overruns poor collaboration among the project participants and inefficient ways of handling the constructed facility during the implementation of the life cycle. BIM plays an undeniable role in increasing the success of project [11]. BIM possesses more positive approach to the construction industry for customer satisfaction, time reduction and cost reduction. BIM is not only made for 3D modelling of building, it can also be used for documentation of project, estimation, energy analysis, etc [12]. A clear understanding regarding the nature of each BIM capability will help the organizations to plan the strategic implementation of BIM on any project and gain systematic, logical and productive results [13]. The inability to identify crucial BIM capabilities is one of the primary barriers to ineffective BIM implementation and slow adoption in India. Successful BIM adoption and implementation by AEC industry in India is foreseen to improve the current status, potential and performance of the industry [13]. BIM implores designers to avoid fudging practices, hence, improving quality and productivity and bringing about best practices. BIM has unique features, it integrates project delivery system, it has unique language to enhance the informative communication between various construction software applications [12]. These BIM capabilities are most important and require maximum attention of BIM implementers to achieve favourable results [13].

BIM in construction management

Participants in the building process are constantly challenged to deliver successful projects despite tight budgets, limited availability of manpower, paced schedules and limited information. The significant disciplines like architectural, structural and MEP designs should be well coordinated, as two things can't take place at the same place and time. Building Information Modeling aids in collision detection at the initial stage, identifying the exact location of discrepancies. The BIM concept envisages virtual construction of a facility prior to its actual physical construction, in order to reduce uncertainty, improve safety, work out problems to simulate and analyse impacts. Contractors from every trade can input critical information into the model before beginning construction work which creates opportunities to pre-fabricate or pre-assemble some systems off-site. Wastage of resources can be minimised on-site and products delivered in expected time.

Quantities and shared properties of materials required for construction can be extracted easily. Scope of construction work can be segregated and well defined.

Features of BIM

The building information model refers to the combined model where the models from the different disciplines have been merged. According to the BIM handbook the Building Information Model is characterized by the following features:

- Components that include data that describe how they behave, as needed for analyses and work processes, e.g., takeoff, specification, and energy analysis;
- Consistent and non-redundant data such that changes to component data are represented in all views of that component;
- Coordinated data such that all views of a model are represented in a coordinated.

Components of BIM

Following are the basic components of BIM. Even though updates and modifications are done every year, the components and its functions remain the same.

B is for building

The key point to mention here is that “building” doesn’t mean “a building”. BIM can be used for so much more than just designing a structure with walls and a roof. This preconceived notion of “building” comes from its origin-in an ordinary sense, it quite literally means “house”. In order to get the true essence of BIM, however, it helps to think of the word “building” in terms of the verb “to build”. It is a process that involves the act of building something together, whether it relates to architecture, infrastructure, civil engineering, landscaping or other large-scale projects.

I is for information

Every aspect of project has some information embedded in it. This is what makes BIM “smart”. Every project comes with a astonishing amount of information, from prices to performance ratings and predicted lifetimes. It tells the project’s life story long before the ground is ever broken and it helps to track potential issues throughout your project’s lifetime. BIM is a way to bring all of these details into one place so it’s easy to keep track of everything.

M is for modeling

In BIM, every project is built twice-once in a virtual environment to make sure that everything is just right and once in a real environment to bring the project to life. This step is the gist of every other aspect of the building and its information. It provides the measure or standard for the building project-an analogy or reduced scale representation of the final appearance and effect. It will continue to model this representation throughout the lifespan of the building.

Objectives

This study has the following objectives:

- To study organizational capabilities and their roles.
- To understand BIM capabilities over traditional methodology.
- Evaluate effectiveness of BIM Tool in construction industry.

Organizational capability

The concept of organizational capabilities can be seen as such a process-oriented concept. A key aspect of this concept is that it enables companies to deal with different types of organizational problems effectively. Organizational capabilities are the inherent capacity or potential of an organization to use its strengths and overcome weaknesses in order to exploit opportunities and face threats in its external environment. Organizational innovations in connection with technical innovations and cultural change also affect the skills and competencies of the workforce. They underpin company's competitive advantages as well as their ability to respond internal and external change. It is the ability of a firm to perform a coordinated task, utilizing organizational resources, for the purpose of achieving a particular end result and allow firms to create new products and processes and respond to changing market circumstances. Organizational capabilities are defined as a firm`s capacity to deploy its resources, tangible or intangible, to perform a task or activity to improve performance define organizational capability as 'the ability of an organization to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result'. Development and cultivation of organizational capabilities can help small business owners gain an advantage in a competitive environment by focusing on the areas where they excel.

The need for the development of new capabilities that represent discontinuous change often originates from changes taking place outside the organization. The knowledge and information required to underpin new capabilities many a times originate outside the organization. However the ability of the organization to exploit this external knowledge depends on the absorptive capacity of the organization itself which depends on the availability of related knowledge within the organization. Acquisition, evolution, and adaptation of capabilities rest on the ability of the organization to learn. Employees of the organization may be technically strong or possess leadership skills, but the organization as a whole may or may not personify the same strengths. Organizational capabilities enable the organization to turn its technical knowledge into the results.

It is better for the organization to excel at a few targeted capabilities than to diffuse their leadership energy over many. The organizational top management must choose a few on which to spend their time and attention to excel in the chosen capabilities. This means identifying which capabilities will have the most impact and will be easiest to implement and prioritizing them accordingly. The remaining capabilities should meet standards of the organization. It is better for the organization to have a distinct identity in some of the capabilities that aligns

with its strategy rather than to be average or slightly above average in every area of work.

An organizational capability emerges from a group of activities, not from any single pursuit. While the organization need to be focused, at the same time it is important to understand that capabilities depend on one another. Even though the organization is targeting some of the capabilities for primary attention in its path to achieve excellence, the most important ones often need to be combined with others. Further as one of the capabilities improves, it probably improves others in turn. Often this improvement happens through a chain process. As the quality of leadership improves, talent and collaboration issues often surface, and in the process of resolving those issues, the organization normally strengthens its accountability and learning. If organizational change does not occur as a single event, which can be analyzed in isolation but has to be interpreted as an experimental process, which has no clear outlines and does not appear as an integral whole, the structural concept of organizational innovation becomes problematic.

Organizational capabilities are rather stable; they do not change rapidly over time. They give a firm its distinctive competitive edge because they have been applied and further developed over a longer period of time. The emphasis is on the accumulation of organizational capabilities and the fact that the options for further development at each point of time are sharply constrained by the tradition of the past. The fact that capabilities are firm specific makes them particularly valuable, because they are of implicit nature and therefore difficult to transfer and to imitate. Organizational capability is built in organisations by aligning the organisational systems and processes represented in the model so as to maximize the alignment of the enablers –the enabling systems and processes at the intersections of the three domains of strategic intent, organisational structures and individual knowledge.

Role of organizational capabilities

Organizational Capability approach implements in an organizational diagnosis only based on how entities acquire what organization consider as relevant knowledge and how they share it at different levels. Organizational capability approach looks for optimally exploiting the internal resources to create significant assets for the organization. It aims at developing the aptitudes of organizations, more and more changing in a turbulent environment by coordinating the continuous learning of corporate good practices by all the organizational bodies. Core capabilities embody proprietary knowledge that is unique to a particular firm and superior to that of the main competitors. It is widely agreed that organization's competitiveness depends on the development of only a few core capabilities. This role of cognition and action in creating organizational capability is critical in the founding of new business strategies so the founders must envisage the required functionality of the new business and take the actions required to turn intentions into reality with superior quality of the output as well as setting a remarkable benchmark in the industry against the competitors and setting up new standards and levels of work ethic at the department level of the firm to motivate the staff.

Characteristics of organizational capabilities

- Organizational capabilities constitute the key aptitudes that a firm must develop and assess to gain a competitive advantage and to determine the status of its strengths and its weaknesses.
- They emerged from the synergies of organizational resources, which continuously progress thanks to the acquisition of knowledge and competencies which are generally modeled under the form of corporate best practices.
- They are thus related to organizational learning and knowledge acquisition, as the cause of organizational capabilities emergence can be an element to assess their development levels.
- The adoption of organizational capabilities generates a performance improvement in the activities of organization. Performance indicators trends, as the results of organizational capabilities emergence can therefore be clues of their development.
- At a local level organizational capability is the synergy of human, physical and structural resources of an entity around the defined strategic objectives. At upper levels organizational capability is the synergy of entities which developed share the same corporate practices and developed locally the same organizational capability.

Types of organizational capabilities

Different types of organizational capabilities and their description is given below:

- Financial Capability

  Financial capability is the combination of attitude, knowledge, skills, and self-efficiency needed to make and exercise finance management decisions that best fit the circumstances of an organization, within an enabling environment that includes, but is not limited to, access to appropriate financial services. It is not enough to provide people with new knowledge about money management and financial services. Those providing financial education should do so in ways that change how a person behaves. In addition, access to formal and semi-formal financial systems is not enough and may not even be productive. It aims at creating an enabling environment that supports the appropriate money management decisions and actions of the organization.
- Marketing Capability

  Creating an effective marketing organisation is about more than just the skills in the team. It's also about understanding what those capabilities are and need to be, translating them into measurable outcomes and making sure that they become embedded into the business. From understanding your current skills and capabilities to helping manage change and measure outcomes there are five stages viz. assess, design, deliver, embed and measure. **Assessing helps to determine** where the organization stands in terms of marketing skills, capability and organisational readiness. **Design helps to build** a practical programme to suit the goals of the organization involving courses. **Deliver**ing keeps track of interactive, practical learning, either face to face, online or a combination of both.

Embedding consists of tools and processes to ensure the learning has long-term adoption and is being used regularly and efficiently in the organization. **Measuring is** a robust approach to tracking outputs and outcomes. It helps to evaluate your programme and justify the business cause for custom marketing training and also helps in predicting the outcome by roughly estimating the probable marketing conditions in the future. It also assists in establishing deadlines for completion of a task sooner than expected that too in a pre-planned manner considering all the possibilities of obstacles.

- Operations Capability

  Operations capability is the ability to arrange critical processes, resources and technologies according to the overall guiding vision and customer based value propositions combined with the potential to deliver these processes effectively and efficiently.
- Personal Capability

  The personal capability helps an organization to continue to develop and improve its practice throughout your career in social services. The personal capabilities focus on how the organization workforce as a social service worker manages your relationships with others in your work. It helps in developing the quality of the professional relationship they have with you that makes the most difference to them and to their lives.
- Information Management Capability

  Information management capability as the ability to provide data and information to users with the appropriate levels of accuracy, timeliness, reliability, security, and confidentiality: provide universal connectivity and access with adequate reach and range; and tailor the infrastructure to emerging business needs and directions.

General organizational capabilities

Organizational capabilities differ from firm to firm. These are the general organizational capabilities which are important in firms of all types.

- Learning

  A learning capability gives an organization an opportunity to master new set of skills. It moves away from the path of generalization and move forward with continuous improvement. The organizational learning can be achieved through training, education and knowledge management. Sharing of experience of successful employees or experts in the field also greatly contribute to learning process. Through learning the organization say good bye to old practices and adopt new one to stay ahead in the market.
- Talent

  A talent based capability assists in identifying the skills of the employees of the organization. To learn or to acquire a particular set of skill, talent is necessary. Every individual has unique skill, competent employees have the skills for today's and tomorrow's business requirements; committed employees apply those skills regularly. Leaders can earn commitment from employees by ensuring that the ones who contribute more receive more of what matters to them. Means of assessing this organizational capability includes productivity measures, retention statistics, employee surveys, job appraisal and direct

observation. Talent management is an important activity for the organization to enhance capabilities. The management to have talent in the organization is to motivate and retain competent and committed people and train the people who fail to perform at the expected level of the company standards. Training can be by means of AV lectures or practical sessions.

- Speed
  It refers to the ability of the organization not only to recognize opportunities but also to act quickly. Whether to exploit new markets, create new products, establish new equipment and technologies, or implement new business processes. Speed plays an important part to keep the organization ahead of its competitors. Speed is needed in the organization for taking decisions and then implementation of these decisions to demonstrate that the organization is having this capability. Just as increases in inventory turns show that physical assets are well used, time savings demonstrate improvements in labour productivity as well as increased enthusiasm and responsiveness to opportunities. Leaders should consider creating a time schedule, so they can monitor the time required for completing a particular task. Speed plays an important part to keep the organization ahead of its competitors. Speed is needed in the organization for taking decisions and then implementation of these decisions to demonstrate that the organization is having this capability.
- Collaboration
  A collaboration based capability helps when an organization as a whole gains efficiencies of operation through the combining of services and technologies. It consists of working across boundaries for ensuring both efficiency and leverage. Collaboration occurs when the organization as a whole gains efficiencies of operation through the pooling of services or technologies, or through the sharing of ideas and talent across organizational boundaries. Evaluate what each division of your company might be worth to a potential buyer, then add up these numbers and compare the total with your current market value.
- Leadership
  A leadership based capability improves market value of organizations that steadily produce effective leaders generally have a clear leadership approach-a common understanding of what leaders should be capable of doing. It moves away from the path of generalization and move forward with continuous improvement. These leaders are easily distinguished from their competitors. You can track your organization's leadership brand by monitoring the pool of future leaders. Seeing the harm to the company's leadership bench, executives encouraged potential leaders to participate in temporary teams, cross-functional assignments and training activities. Through learning the organization say good bye to old practices and adopt new one to stay ahead in the market.
- Customer Connectivity
  The ability to connect with targeted customers is strength of the organization. Customer connectivity may come from devoted account teams, databases that track preferences, or the involvement of customers in HR practices. When a large portion of the employee population has meaningful exposure to or interaction with customers, connectivity is enhanced. To monitor this capability, the organization should identify their key accounts and track the share of those important customers from time to time. Regular customer-

service surveys may also offer insight into how customers perceive your connectivity. Identifying customers and their understanding interactions when they are utilizing the service and then using that information in conjunction with context to push the right content is a key to achieve customer connectivity, effectiveness of the customer experience.

- Innovation
  Innovation is doing something new in both content and process. Innovation capability is defined as the ability to absorb, adapt and transform a given technology into specific operational, managerial and transactional routines. By doing so, a firm can perpetuate itself overtime. Innovation in products, administrative processes, business strategies, or customer service focuses on the future rather than on past successes. It excites employees, delights customers, and builds confidence among investors. This capability may be tracked through a vitality index. Innovation can emerge from any one of the complementary capabilities. If technological innovation is perhaps the most evident and charming type of innovation, not all firms are able to technologically innovate. In short, the organization's innovation capability is the ability to provide new valuable solutions validated or expected by the market. Innovation initiatives are easy to begin, all it requires are ideas. Teams are formed and enthusiastically begin their hunt for new ideas that help the company better serve their customers and develop new platforms for future growth. Innovation processes therefore demand the diffusion and integration of a great number of knowledge sources and continuous reconfiguration of various knowledge elements available. A link between performance management and innovation capability can be established by using appropriate performance measures for enhancing the effect of innovation capability on performance of the firm.
- Efficiency
  Efficiency may be the easiest capability to track. Inventories, direct and indirect labour, capital employed and costs of goods sold can all be viewed on balance sheets and income statements. While it's not possible to save your way to prosperity, leaders who fail to manage costs will not likely have the opportunity to grow the top line and they may not be a part of the organizations in its future endeavours due to lack of efficiency.
- Strategic Unity
  Strategic unity in the organization is created at three levels namely intellectual, behavioural, and procedural. To have such unity at the intellectual level, it is to be ensured that the employees from top to bottom know what the strategy is and why it is important. There has to be shared understanding amongst the employees about the strategy of the organization. At the behavioural level, employees are to spend their time in support of the strategy and also to give their suggestions for improvement. As regards procedural level the organization is to continually invest in its procedures and practices that are essential for the implementation of the organizational strategy.
- Accountability
  Accountability becomes an organizational capability when employees realize that failure to meet their goals would be unacceptable to the company. The organization must obtain high performance from its employees for enhancing its capabilities. For enhancing the accountability, the organization is to

examine and modify the tools being used to monitor and manage the performance of the employees.

Traditional approach used before BIM

Traditional methods of construction have been adopted for building a lot of structures erstwhile. However, a lot of incidents causing havoc have led to the questioning of many traditional practices. In the traditional method of designing each of the specialists work on separate industry drawings (prepared on tracing papers) with only those elements for which they are responsible. The methods that have traditionally been used for the elaboration of construction projects have always had several downsides that are currently being solved with the evolution of the BIM methodology. Tracing papers produced by specialists are imposed on each other during the coordination meeting to check the compatibility of the project. By distinguishing the processes into their dimensions, we can compare both methodologies according to their performance**.** Implementation of BIM give those working in the construction sector an alternative approach; rather than using the traditional prime contractor methodology, integrated project teams can be created. These can be made up of personnel from the client organization as well as various contracting and engineering teams. More importantly the management of contracts and their integration with key aspects of the relationships established for accomplishment of the project can be elevated to maximum effect. To adopt such a technique, the organizational capabilities need to be improved.

Building information modeling

Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. BIM provides a platform for sharing knowledge resource for information about a facility forming a dependable basis for decisions during its life-cycle; defined as existing from earliest completion to demolition. Traditional building design was largely reliant upon two-dimensional drawings (plans, elevations, sections, etc.). Building information modeling extends this beyond 3D, augmenting the three primary spatial dimensions (width, height and depth) with time as the fourth dimension (4D) and cost as the fifth (5D). BIM therefore covers more than just geometry of the model. It also covers spatial relationships, light analysis, geographic information, and quantities and properties of building components.

BIM involves representing a design as combinations of "objects" – vague and undefined, generic or product-specific, solid shapes or void-space oriented that carry their geometry, relations and attributes. BIM design tools allow extraction of different views from a building model for drawing production and other uses. These different views are automatically consistent, being based on a single definition of each object instance. It also defines objects parametrically; that is, the objects are defined as parameters and relations to other objects, so that if a related object is modified, dependent ones will automatically also change. Each model element can carry certain attributes for selecting and ordering them automatically, providing cost estimates as well as material tracking and ordering.

For the professionals involved in a project, BIM enables a virtual information model to be handed from the design team (architects, surveyors, civil, structural and building services engineers, etc.) to the main contractor and subcontractors and then on to the owner/operator; each professional adds discipline-specific data to the single shared model. This reduces information losses that traditionally occurred when a new team takes 'ownership' of the project, and provides more extensive information to owners of complicated building structures.

Building Information Modeling (BIM) is one of the most recent technologies introduced to the design and construction industry. Currently, some industrial institutions are requiring a BIM component for commencing new construction activities. A survey inquiring about the current use of BIM, its benefits, perceived barriers to using BIM and the importance of particular BIM procedures were distributed to architecture, engineering and construction (AEC) professionals who have experience with educational facilities projects. The survey responses were analyzed using descriptive statistics. The survey results showed that the majority of the companies were using BIM. Many of the professionals who do not use BIM claimed to have no interest in using BIM. The largest proportion of the respondents perceived clients to be the driving force behind the use of BIM on educational facilities projects. Most respondents agreed that BIM was useful for increasing client engagement by providing clearer understanding of the projects through 3D visualization. While most of the respondents believed that design-build was the best method to deliver educational facilities projects using BIM, the majority of the respondents still used the old and conventional design-bid-build method.

If BIM is compared with traditional methods, there is no possibility of forgetting to update changes made in the design because any change in any view is automatically updated in all relevant plans, views, sections and elevations. For example, lines are used to draw wall in CAD and if width, height or length of wall is needed to be changed, it should be changed manually and all other related parameters should be changed one by one that increases the risk of forgetting to update changes. However, BIM facilitates design change process because if any design changes occur in model, it is automatically updated in other related models therefore it reduces possibility of errors and omissions that may occur in CAD design.

BIM periodic table

The Periodic Table of BIM is a guide to the steps we need to take to ensure a successful BIM implementation. Taking its inspiration from the periodic table of elements, this table presents all the main elements of BIM in a lucid manner. Periodic table of BIM indicates what is needed to consider when thinking about software, hardware and appropriate training required plus the file storage required for the new digital files. There are a lot of parameters to be considered when establishing BIM infrastructure. The table is divided into following groups:

- Strategy
  Clearly define your BIM strategy and understand what the company is trying to achieve using BIM. Consider how and when to implement the strategy and the

supporting foundations, processes, technology, tools and personnel that you require. A clearly defined strategy is at the heart of a successful BIM implementation, so its inclusion at the head of the BIM Periodic Table in a 'BIM STRATEGY' grouping all of its own. These measures would all be achieved through more efficient access to shared information about built assets, something that lies at the heart of BIM.

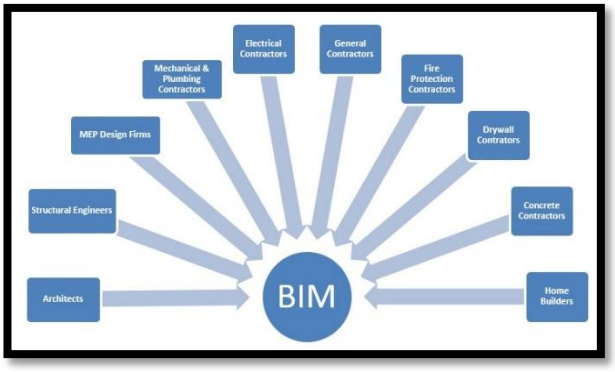
- Foundations
  Build foundations of efficient systems for communication, information exchange and data transfer to underpin advanced BIM processes. Create an approach for managing the production, distribution and quality of construction information and consider the right procurement route that will set the appropriate environment for collaboration. Establish the current BIM capability and capacity to determine the BIM readiness status and think about the practical changes that may require in the future. Foundations are the bedrock of efficient systems for communication, information exchange and data transfer. Only with these in place you can start to build advanced BIM processes.
- Process
  Consider how and where you can make improvements in your current processes. Understand what a best-practice workflow looks like and ensure that information is universally structured regardless of author. Understand information requirements during the whole project life cycle so that best value is achieved through the whole project time line.
- People
  People are an element of a BIM strategy which is often overlooked. Provide clear communication to your colleagues as to why and how you intend to implement BIM and gain support by engaging BIM champions, as well as getting support from senior management. BIM implementation requires changes in process so make sure that you share success among the team and provide individuals with the support and training that they may require.
- Technology
  Ensure that you have the right technology i.e. software and hardware to support the BIM aims and objectives. As you move into a digital environment, consider how and where data is stored and the best way to share and publish information in a secured way.
- Standards
  Understand the standards, procedures and supplementary documents available that will assist with your strategy and help achieve collaborative BIM. More countries around the world are embracing BIM either as a top-down approach such as mandating BIM at a government level or a bottom-up approach such as a demand from the supply chain. The **standards** grouping takes in a range of standards, procedures and supplementary documents that have been developed to 'bake in' the kinds of considerations and assurances that will help you devise and then implement a successful BIM strategy.
- Enabling Tools
  Consider the enabling tools that will help design, develop, deliver and maintain the built asset in good condition. It may require a number of different enabling tools for specific tasks and functions. Before you make an investment consider what tools are available readily.

- Resources
  Make use of access to information by considering what resources are available to you. The internet and social media have created a valuable online community of support.(Refer fig. 1)

Figure 1. BIM periodic table

BIM in Construction Industry
Introduction

The versatility and flexibility of BIM workspace provides a wide range of applications in the construction industry. Personnel belonging to each and every core area can use it for their specific purposes.



Workflow of BIM

The workflow of BIM is as per the flowchart given below. The flow chart illustrates the top-down approach and interconnectivity between the contributions of work from various sectors. When all the necessary data is available the final model is prepared and then the work can be carried out as per the model. 3D realistic model makes it easier to track the work on site. Many construction professionals forecast more confidently and deliver projects more successfully using Building Information Modeling (BIM). With greater insight into designs and more accurate data, construction professionals can plan, coordinate and control project

outcomes more efficiently. BIM offers the tools needed to evaluate and enhance the constructability of designs to reduce delays, errors and cost overruns.(Refer fig. 3.2)

Applications of BIM

The application of BIM can be divided into following areas:

- Design
  Building is designed with intelligent objects and architects, structural engineers and MEP engineers can work on the same building model due to the object-based parametric modeling feature available in BIM. Due to the practicability of BIM, design process can be facilitated and more accurate construction drawings and high quality 3D renderings of building can be prepared. The object-based parametric modeling feature in BIM allows architects, MEP engineers, structural engineers and fabricators to grasp multiple functions on the same building model for their own use. With accurate building information and object models, the design/modeling process is dramatically facilitated. The design accuracy and information sharing enhancement span all the phases of the design/modelling process which also benefit the subsequent activities for the project control.
- Quantity Takeoff
  Quantity takeoff is the most important part of cost estimation and quantity surveyors are responsible from bill of quantity calculations. Length, height, number of items, perimeter, area, volume and weight are the most recurrent measurements in bill of quantity calculations. BIM users can generate accurate and reliable cost estimates through automatic quantity takeoff from the building model and get a faster cost feedback on changes in design. It is possible to make all the involved organizations aware of the cost associated with the design before it progresses to a more detailed level. Bill of quantities is calculated by measuring necessary dimensions and calculating perimeter, area and volume manually.
- Energy Analysis
  The capability to link the building model to energy analysis tool enables users to carry out the energy analysis in the early design phase of the project. Traditionally, a separate energy analysis would be conducted at the end of the design process and it is not possible for users to modify the design to improve the building's energy performance. By means of BIM, the building model can be linked to the available energy analysis tools for the energy evaluation before commencing the construction project. The analysis allows users to make energy-conscious decisions and to test the energy-saving ideas without postponing the adopted design process.
- Interior Designing
  Interior designers use 3D views to generate basic renders for their clients. This is an opportunity for designers to impress and discuss their ideas for the layout for a given space within the building. It's in this phase that the designer showcases the furniture in the space, making it even easier for manufacturers to offer accurate representations of their products. Adding non-graphic data within the individual symbols enables interior designers to perform accurate

quantity calculations in relation to surface areas and material amounts with ease.

- Collaboration
  Model based collaboration helps for the generation of a digital representation of the entire construction process. Multiple project stakeholders are involved in the realization of the realistic model. The idea of directly using a single model in a centralized storage containing all information of a project has been excluded for multiple reasons. Firstly, project stakeholders do not want to share models, which have not yet finalized. Due to contractual conditions, the models cannot be shared beforehand. The usage of a single model may cause an information overlap between the different disciplines, causing misinterpretation of task assignments. (Refer fig. 2)

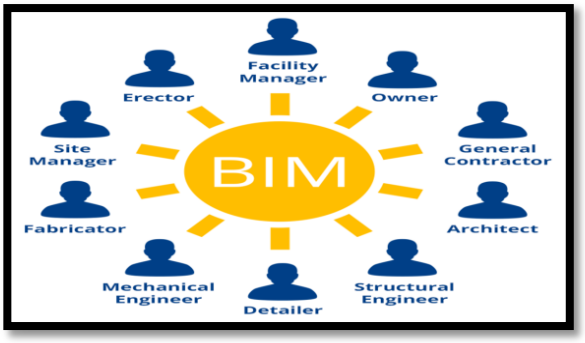


Figure 2. Collaboration using BIM

- Linking and Extending
  If storeys are to be increased of an existing building, the model of the built structure can be prepared and aspects of update can be decided based on the characteristics of the model of existing structure. Once the appropriate update model is chosen, the new model can be linked with the old model and if there is no clash detected during linking the same prototype can be extended and finalized.
- Solar study
  Illuminance is a measure of how much light falls on a surface. It is useful for determining whether or not there is enough light to perform different activities (like reading, office work, drafting etc.). We need approximately 50 to 1000 lux for activities inside a building depending on the activity. An illuminance rendering shows you whether your lighting design meets the requirements of the space and it also helps you understand how much of this light we will be able to get from day lighting. Solar study feature in BIM helps to identify and improve the lighting in a building during daytime so that electricity usage is not required during daytime.

Benefits of Implementing BIM

BIM has following benefits over traditional methodology:

- Captures Reality
  The wealth of information that's accessible about project sites has expanded greatly with better mapping tools and images of Earth. Today, project starts include aerial imagery and digital elevation, along with laser scans of existing infrastructure, accurately capturing reality and greatly streamlining project preparations. With BIM, designers can have all of that input compiled and shared in a model—in a way that paper isn't able to capture.
- Less need for rework
  With a shared model, there's less need for rework and duplication of drawings for different requirements of building disciplines. The model contains more information than a drawing set, allowing each discipline to annotate and connect their intelligence to the project. BIM drawing tools are faster than 2D drawing tools, and each object is connected to a database. The database aids such steps as the number and size of windows for quantity takeoffs that are updated automatically as the model evolves. The quick, computerized counting of components alone has been a significant labour and money saver.
- Maintains Control
  The digital model-based workflow involves such aids as auto-save and connections to project history so that users can be certain they've captured their time spent working on the model. The connection to the version history of the model's evolution can help you avoid disastrous disappearances or corruption of files that can make blood boil and impinge productivity.
- Improves Collaboration
  Sharing and collaborating with models is easier than with drawing sets because there are a lot of functions that are possible only through a digital workflow. Much of this added project-management functionality is now being delivered in the cloud. Here, there are tools for different disciplines to share their complex project models and to coordinate integration with their peers. Review and mark-up steps ensure that everyone has had input on the evolution of the design, so they are ready to execute when the concept is finalized and moves to construction.
- Simulate and Visualize
  There are an increasing number of simulation tools that allow designers to visualize such things as sunlight during different seasons or the calculation of building energy performance. The intelligence of software to apply rules based on physics and best practices provides a complement for engineers and other project team members. The software is able to do so much more of the analysis and modeling to achieve peak performance, condensing knowledge and rules into a service that can run with the click of a button.
- Resolves Conflict
  The BIM toolset helps automate clash detection of elements such as electrical conduit or ductwork that run into a beam. By modeling all of these things first, clashes are discovered early, and costly on-site clashes can be reduced. The model also ensures a perfect fit of elements that are manufactured off-site, allowing these components to be easily bolted into place rather than created on-site which reduces chances of errors.

- Enhanced coordination
  With a model and accurate set of sub-models for each phase during construction, the next step is a coordinated sequencing of activities, materials, and crews for a more efficient construction process. Complete with animations, the model facilitates coordination of construction activities and processes, delivering a predictable path to the expected outcome.
- Advanced Customization
  The model is a great end point for a lot of knowledge transfer, but there's also a need to share a traditional plan, section, and elevation, as well as other reports with the rest of the project team. Using automation and customization features, these added sheets can save valuable drafting time.
- Perfect Presentation
  With all of the design completed on a capture and alteration of existing reality, the model is the ultimate communication tool to convey the project scope, steps, and outcome. The fact that the design is fully 3D also means that there are fewer steps to render impressive views and fly-through that can be used to sell commercial space or gain necessary regulatory approvals.
- Digital Documentation
  With the added benefit of a model that's tied to a database, you have a great deal of intelligence at your fingertips. Combining this capability with the cloud means that you have access to the model and project details from anywhere, on any device.

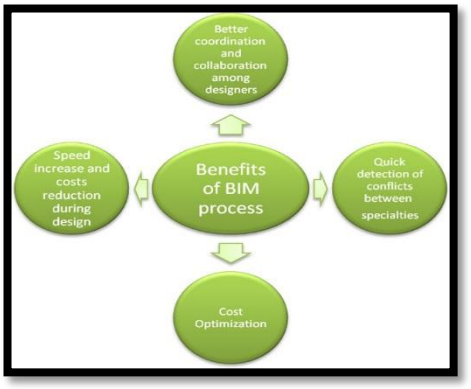


Figure 3. Benefits of Implementation of BIM

Barriers in Implementing BIM

The slow adoption of BIM is linked with many different barriers, and there is no single one problem that could be solved individually to enable wide scale BIM adoption. Following are the different barriers.

- No client demand
  Whilst the Government is in the process of enforcing BIM for publicly-funded work, clients of smaller organisations don't often make similar demands – and the smaller they are, the less likely this is.

- Misconception about relevancy
  71% of small firms felt that BIM simply isn't applicable, or appropriate to the nature of their typical workload. They may feel that there isn't the level of complexity to warrant BIM, but the fact is that even domestic projects can be complex in nature depending on the arrangement of the structural elements and the conditions present on site may or may not be easy to assess.
- Cost
  A common observation was the 'need to get through the downturn' before looking at BIM. The recession has increased cautiousness, particularly when it comes to financial outlay. And it can't be denied that the move does involve expenditure on software, training, and time. But the costs need to be weighed against the potential benefits. Those who have adopted BIM tend to report that the experience has been better than they had anticipated.
- Lack of perception
  Contrary to common perception, BIM can work on any size of project from a domestic refurbishment upwards – the biggest inhibitor to its effectiveness is the quality of the survey undertaken, but this is in fact the case regardless of whether a building is drawn in 2D or 3D. Although small contractors are likely to provide resistance to technological changes in working practices initially, the workplace is nevertheless evolving all the while, and the benefits can still be realised during the earlier stages of a project in the meantime.
- Lack of expertise
  62% of practices expressed this concern, and 77% of practices with six or more staff. Although organisations – particularly smaller practices – may not currently have the skills in-house, the upturn in the industry is leading to an increase in recruitment, and this is the ideal time to recruit staff with the necessary skills.

Conclusion

On the basis of the literature review collected and the results of the case study carried out, the contribution and potential of BIM to improve the organizational capabilities is identified in this study. Following are the deductions assimilated from this study:

- 7 out of 10 organizational capabilities can be improved by adopting BIM in a firm.
- Using conventional approach it took 21 days and 4 people to get it done but by using BIM it took only 9 days and 1 person.
- Different callouts were possible to extract the working data required from a single model.
- BIM provides platform for assessing all possible permutations and combinations using a unique source.
- BIM is stronger than conventional methods in each and every aspect.

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