



Exploring the journey of BIM in the Indian AECO industry (2008–2022) an excelize perspective

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Abstract The journey of Building Information Modeling (BIM) in India has been from skepticism to acceptance to leveraging the higher potentials of BIM. Excelize Software, serving the global Architecture, Engineering, Construction and Operations industry from their headquarters in Aurangabad, has been a witness to and participant in this transformational journey for nearly last two decades. This paper is aimed at exploring their journey of offering BIM services to a wide variety of projects that were undertaken in the construction industry of India during this period. The construction sector has historically grappled with the challenges of managing productivity with respect to completion of projects on time, management of labor and materials and maintenance of built assets. BIM made its foray into the Indian construction industry towards the end of the first decade in this millennium. Typical of any technology adoption curve, BIM was met with a fair share of skepticism across stakeholders. Yet, awareness about its potential benefits, scope of application in design and management of various aspects of the project and subsequent adoption has grown slowly yet steadily in the past decade. Data published by Invest India (*Source: <https://www.investindia.gov.in/sector/construction>*) states that the construction Industry in India is expected to reach \$1.4 Tn by 2025. Urban population is said to contribute 75% of GDP (63% present), and 68 cities will have a population of more than 1 million; up from 42 today. The construction

industry market in India works across 250 sub-sectors with linkages across sectors. Given these projections, India is likely to go through massive urbanization and economic growth. All construction activities that result from this growth will need proper planning, scheduling, design and information management. Meeting these needs will require a strong framework for implementation, a sophisticated level of design communication, project co-ordination and documentation as well as robust technology tools. BIM is well-designed to be the first building block of such a framework that can radically support and enhance the massive needs of the construction sector in India. Through the various projects executed by Excelize and a set of parameters that reveal the BIM adoption metrics for the said period, this paper will navigate the journey of BIM from '*We are not interested*' to '*Nice to have tool*' to '*Must have technology aid*' to '*Exploring BIM for greater possibilities.*'

Keywords Building information modeling (BIM) · BIM adoption · BIM benefits · BIM implementation

1 Introduction

The shift of design communication from 2D (Computer Aided Design) CAD drawings to 3D models which simulate the project, has been a turning point in the history of construction and architecture. BIM models came into the picture as a design aid for 3D modelling, which could help architects and builders, visualize and guide the project to precision. Such a model outdoes the limitations of 2D drawings and integrates all relevant data in the construction lifecycle of the project. The ability of BIM models is to assimilate and integrate data with precision and enhances

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the clear and crisp communication among project stakeholders (clients, architects, engineers and contractors). It is also the stepping-stone for application of advanced technologies such as artificial intelligence, robotics, and others in the construction industry. Excelize founders are optimistic that technology is going to be a key enabler for the AECO industry in the times to come. BIM also has a critical role to play in larger aspects such as safety, sustainability and facility management. In all, BIM is certainly a tool that will catapult the Indian AECO industry to its next wave of growth.

BIM is not just a technology offering; it leads to design thinking, logical thinking, analytical and critical thinking and enables a process that catalyzes operations. The adoption of BIM has also been influenced by policy implication and construction standards. It is safe to say that BIM has the potential to be the nucleus of information management for all projects, irrespective of location, standards, scale, afterconstruction use, nature of construction and others.

BIM in the Indian context has walked the journey from ‘We are not interested’ to ‘Nice to have tool’ to ‘Must have technology aid’ to ‘Exploring BIM for greater possibilities’ from 2009 till date.

The graph below illustrates this journey of BIM in a snapshot (Fig. 1).

2 BIM implementation across the globe

USA and the UK are the leading BIM implementing countries in the world. Australia is one of the adopter countries whose rapid performance is outperforming the

more established countries in terms of BIM guide, standards, national specification, and corporate research center.

US government enforced BIM to improve productivity and performance of government-built assets, UK was inspired by the possibility of reducing capital costs and carbon performance and for Australia, the BIM initiative aimed to increase productivity and improved asset management in the built industry. These countries also lead the wave in terms of education, technology and research (Fig. 2).

2010: The United States is one of the pioneers in BIM development and adoption in the construction industry. In the US, the General Services Administration (GSA) in 2003 launched the “National 3D-4D program” with the goal to form strategy to gradually implement 3D, 4D and BIM for all major public projects. In 2007, the GSA included BIM for spatial program validation for all its projects.

2011: The Scandinavian countries are at the forefront in BIM adoption [1]. In the Netherlands, the Government Buildings Agency has mandated the use of BIM for public projects in 2011 [2]. Research conducted in Germany, France, Brazil and Austria showed that BIM is gaining wide adoption in these countries [3]. In Estonia, a survey was carried out among 297 firms and revealed that 51 per cent of respondents are already using BIM or planning to adopt it over the next 5 years [4].

2014: The European Commission announced directive 2014/24/EU, which recommends member states’ use of specific electronic tools such as BIM for public works contracts and design contests. In the United Kingdom, the government has mandated a minimum of Level 2 collaborative BIM on all publicly financed projects from 2016 [5].

Fig. 1 Interest in BIM adoption

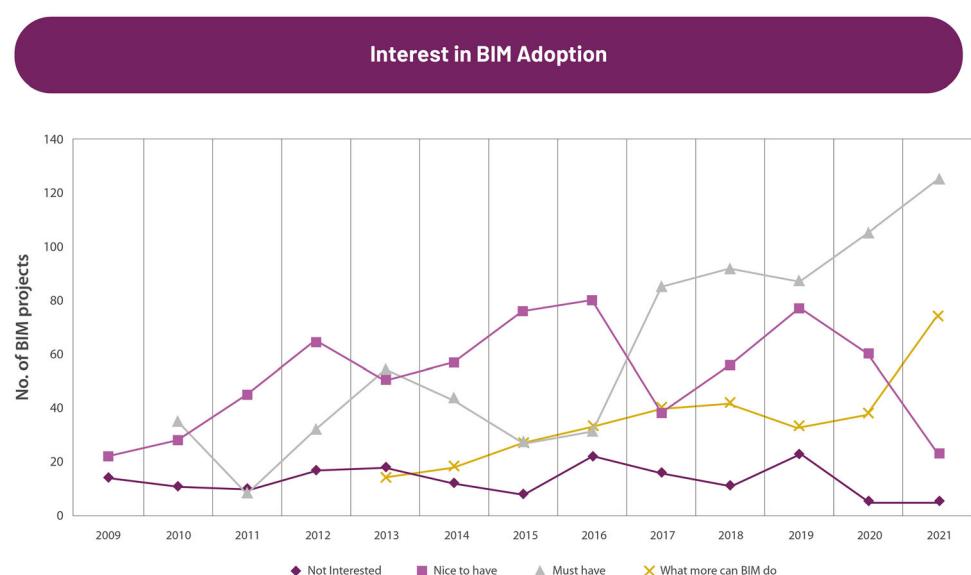
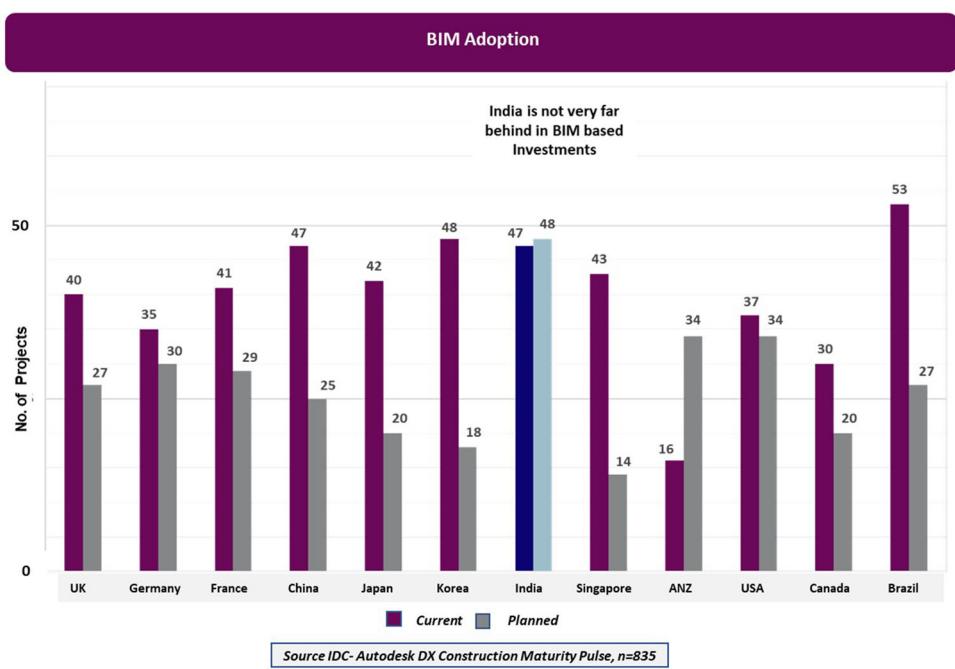


Fig. 2 Global BIM adoption

2015: Singapore mandates the use of BIM in all publicly funded projects.

2016: UK government introduced the BIM mandate to help achieve—33% reduction in the initial cost of construction & whole life of built assets, 50% reduction in the overall time, from inception to completion, for new build & refurbished assets, 50% reduction in greenhouse gas emissions in the built environment and 50% reduction in the trade gap between total exports & total imports for construction products & materials. The mandate asks for a minimum of Level 2 collaborative BIM on all publicly financed projects. The industry backed the Government's BIM direction. South Korea mandates the use of BIM in all publicly funded projects.

2017: In Hong Kong, the government mandated the use of BIM in the design and construction phases of all public projects.

BIM has been evolving across the globe and its acceptance is increasing all across for a better and fast growing AECO industry.

3 The multiple facets of BIM in India

3.1 Awareness about the potential benefits of BIM

In the beginning of this millennium, there was a noticeable shift in the volume and nature of buildings being constructed. Buildings with advanced HVAC (Heating, Ventilation and Air Conditioning) systems, security needs and energy requirements were on the rise. While 2D CAD

drawings were being created and accessed in digitized formats, they continued to be an aggregation of unintelligent lines and text. There was an incumbent need for an interactive tool which simulates the complexities of the project closely, assembles all information at one place and cross-links the data among all objects of the model.

This gave rise to the initial interest in BIM. However, most people in the industry weren't initially interested in this tool. The unfamiliarity of a new technology tool, lack of expertise, costs involved, unwillingness to change the traditional practices and other such factors posed as initial deterrents to adoption of BIM. In the next 5–7 years, BIM earned the status of 'Nice-to-Have' tool. Many began to see it as a better design tool, some experienced increased demand from their clients, or were told about the cost saving aspects in the long term and yet others, began to see using it as a competitive advantage.

Around 2015 onwards, project stakeholders began to see BIM as a 'Must Have' tool. A paper published by the Asian Journal of Civil Engineering stated that there was a sharp increase in the awareness among the construction professionals in India as per the 2019 survey conducted by the Journal. Most BIM users claimed to have worked on Revit as a major BIM tool. Even in that year, non-BIM users mentioned that they were better off with Auto CAD as a design tool.

Come 2021, BIM has graduated from 'Must Have' tool to 'What More Can I do with BIM'. There's a newfound interest around advanced applications of BIM such as integration with Enterprise Resource Planning (ERP) to help manage material procurement, bill verification and

cash flow. Other applications such as calculation of cost over runs and cost to completion based on current construction progress and baseline helps with better catch-up planning. During operations and maintenance stage, locating and accessing assets, identifying challenges in accessing the assets are some functionalities which spark interest, as also seen in customers of Excelize.

The awareness about the various benefits of BIM and their application has been a gradual process. In its own journey, Excelize has seen the shift from customers being completely disinterested in exploring BIM to exploring the basic benefits of BIM like design co-ordination and clash detection to clearly identifying metrics for BIM modelling services to setting up mandatory BIM frameworks at an organization level.

This could be seen in the Request for Proposal (RFP) documents drafted by customers, allocation of dedicated team and infrastructure, decision making approach by teams, involvement of teams in applying the information from the models to the construction onsite and so on. An elaborate BIM Execution Plan (BEP) is still not so common in AECO projects but there has been a clear impetus towards BIM implementation at a policy level for public infrastructure projects as well as private sector projects. As of 2021, the conversations have moved towards advanced applications of BIM, yet there's a long way to go as far as complete dissolution of resistance is concerned (Fig. 3).

3.2 Drivers of BIM adoption

Building information modelling (BIM) is viewed as an “epochal transition” in design practice [6]. Roles and

responsibilities of major stakeholders are changing due to the ongoing adoption of BIM. For architects, it brings in changes in the design practices, design culture and effort expended on non-value-added activities reduced. So, architectural firms have been the early adopters of BIM. Ease of visualization and better presentation to end customers drew architects towards using BIM. As contractors noticed that BIM adoption yields efficiency gains, better and faster project co-ordination, accurate procurement of materials and scheduling of tasks, they began to demand application of BIM for greenfield construction projects as well as brownfield projects (Fig. 4).

Owners or developers were the next group to adopt BIM. The ease of visualization that is offered in the design phase was a driver for mandating design consultants to adopt BIM. During the construction phase, this group could reap benefits such as—transparency in project co-ordination and communication, estimation of material and project costs, procurement or planning for materials, and tracking and monitoring of construction schedules.

3.3 BIM maturity

One of the factors that radically affects BIM implementation is the availability of skills/technical expertise, cost of training and implementation, and related aspects of the technology or design teams on the project. The survey conducted by—India BIM Association (IBIMA) in 2016 reveals that BIM maturity in India falls under the design stage. Indian firms typically are using BIM for design and drawing purposes. 37% of respondents in the survey rated

Fig. 3 Benefits of using BIM—automation of quantity surveying (Case: The Dubai Mall)

Benefits of using BIM – Automation of Quantity Surveying (Case: The Dubai Mall)

BIM Benefits due to BOQ

Overall construction cost \$1.3 billion, 2 million sq. ft. total area

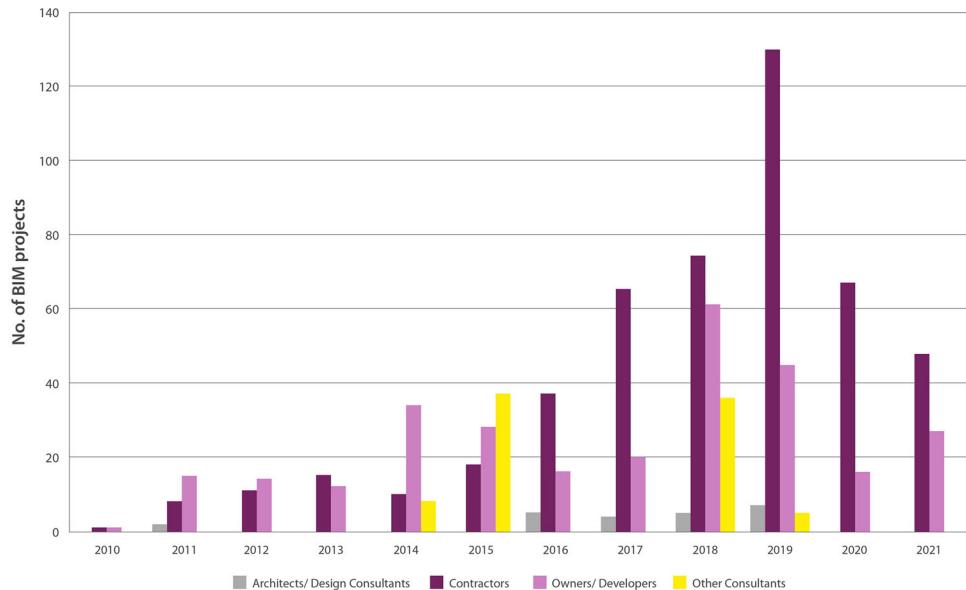
The Actual time saved by automating the quantity surveying task was
 ➤ 700 man-months
 ➤ Improved efficiency of 86%
 ➤ Overall saving of \$7 million

Accurate material take-off allowed procurement of exact quantity of concrete needed—no more, no less

This eliminated the need for a normal material contingency, thereby reducing waste by 5% and saving \$3 million in wasted concrete

In total \$10 million **SAVED** by adopting the integrated and automated BIM/QS process.

Fig. 4 BIM adoption by stakeholders

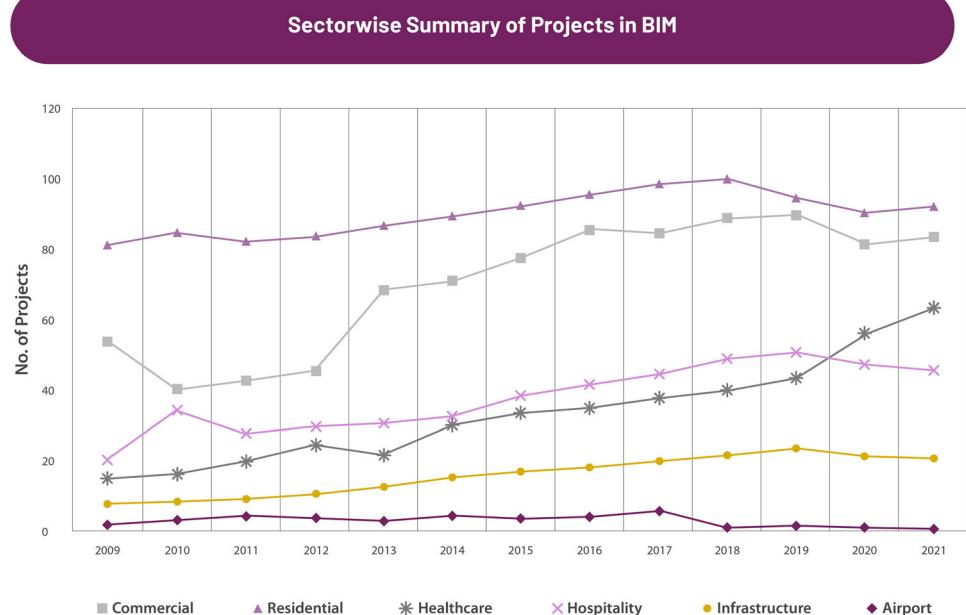


their knowledge of BIM as very good. When asked about the provision of BIM training to the organization, 40.96% of respondents reported that they get ‘Inhouse training of BIM’ and 34.5% reported ‘self-learning using learning platforms (Fig. 5).

In 2016, hardly any of the respondents claimed to have got trained for BIM in their university/college studies in India. If BIM is introduced in the curriculum, the next

generation of BIM practitioners are likely to be well-informed and aware of its potential. Currently in 2022, technology adoption and integration has become a part of the academic curriculum in many architecture colleges in India. There’s also active engagement of international academicians in advisory capacities to spearhead the process.

Fig. 5 BIM adoption by sector



3.4 Barriers to BIM adoption

If we look at the barriers that inhibits or slows down BIM adoption anywhere in the world, the most evident barrier among them is the resistance to change. This primarily includes resistance to adopt technology and to unlearn and relearn existing methods of approaching design, communication, and project management.

Barriers to BIM Adoption also includes softer aspects like internal culture change, which the management needs to lead top-down. It is a chicken-and-egg story: whether one should experience the benefits of BIM first or dive deep into investing in it which then opens up multiple avenues. In any case, it is certain that in order to realize the benefits of BIM, it needs an investment of time, cost, people, processes and thus, heralds a cultural change in the teams working with these models. In the early experience at Excelize they found that developers had a sense of the benefits that adoption of BIM and other technologies would bring to them, but they were resisting a change. They had a democratic process where the decision was left to the team and the teams were not ready to move out of their comfort zones.

BIM was projected to be a magic wand that would solve all problems but in reality, it was a handshake between the various project teams and organizations.

Another barrier was resistance to change and technology adoption. The project and on-site teams involved were comfortable with their traditional approach to design and construction resisted any new approach/solution even if that meant solving the inherent challenges of the traditional approach. The cultural change to improve the process was not something they were inclined towards.

Post the global housing and economic crises, there were a lot of global players entering the design market in India. Mega projects were conceived, and this development called for better technology adoption.

3.5 BIM mandates

The impetus for BIM implementation gains momentum when the deployment of BIM is mandated at an organizational or a government level (regulatory framework).

In India, currently there is no BIM mandate. The adoption of BIM has been primarily driven by the users at project level. The success achieved by these projects then encourage progressive adoption of BIM at an organization level. Most of the adoption has been in private sector. In the public sector, we have seen Special Purpose Vehicles (SPV) set up who are driving BIM adoption through mandates (Fig. 6).

The journey of BIM mandate for Excelize had started with a BIM implementation project for coordination alone.

The BIM goals included quantity extraction for estimation in the design phase and for bill verification during construction in the next project. In the past 2 years with the world grappling with Covid, BIM adoption has increased horizontally, with multiple design firms adopting BIM. This has been influenced by the mandates by the developers in the private sector.

Public sector has been quicker to mandate BIM primarily governed by the size of projects and the ease of cost management through BIM services. Post the implementation of 5D BIM at MAHA Metro in Nagpur, almost all metro development projects in India are now mandating 5D BIM. Similarly, infrastructure projects are now going beyond BIM mandates and talking about mandating digital integration platform for construction management and beyond for asset management during the lifecycle of the development. This includes integration between 3D models, project plans for construction simulation and monitoring and integration with ERP tools for 5D cost management.

3.6 BIM standards and implementation framework

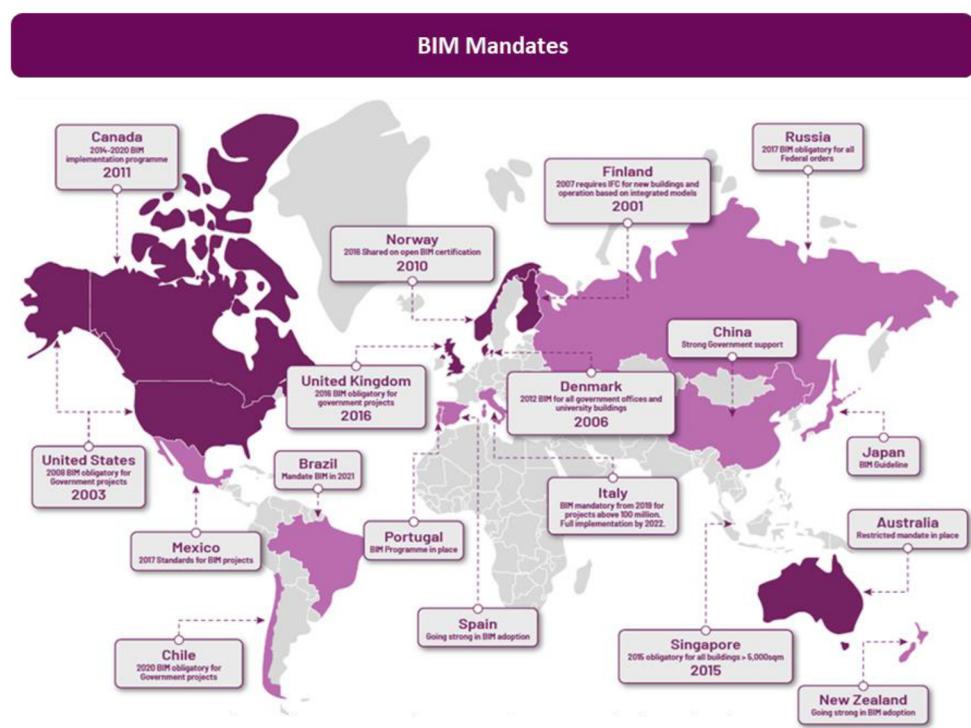
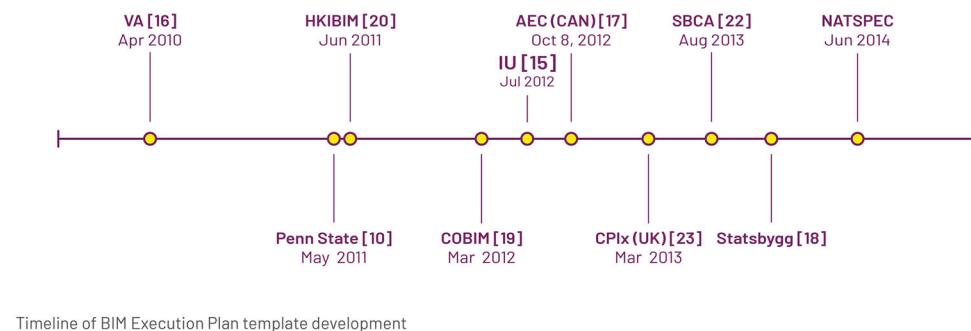
Though BIM is a technology that can be pivotal to enhancing productivity and optimizing costs for the construction, it is not guided by a set of standards or rules for its implementation. The standards are left to be defined by project teams/users and vary across the board.

As there is no single body mandating BIM, the standards and implementation framework has been decided largely by users. BIM Execution Plan (BEP) is the first attempt at creating a framework and standardization of processes involved.

Back in 2010, Excelize worked on an airport project, wherein no BEP was generated, no standards for the project were documented. In 2014, the Excelize team worked for an IT giant who was setting up 10 campuses in India. 2 BIM consultants were working on this project. While BEP wasn't generated for this project as well, the standards were setup and made mandatory too.

In 2015, the BEP for MAHA Metro was well detailed and thought out by Excelize. It was generated in consultation with all the stakeholders and owners. As part of the BEP, employers' information requirements, master information delivery plan, task information delivery plan, Level of Details (LOD) matrix, Level of Information (LoI) guidelines, were documented and implemented. BS PAS 1199 standards were followed for this project. It is interesting to note that many localized standards had begun to evolve, notably, Build Smart, NBS, Singapore BIM standards, HK BIM guide, etc. (Fig. 7).

Since 2020–2021, we have many tools that allow us to generate the BEP. Based on the project or organization

Fig. 6 BIM mandates**Fig. 7** BIM standards

goals, BEP can be generated to various global standards. There is a movement which insists on adoption of a uniform, global standard i.e., ISO 19650. Besides, there is a big movement globally to get a BIM organization certified with the Kitemark; a global BIM adoption standard that organizations can follow.

Along with this surge in BIM adoption, we are also seeing the user base grow exponentially. In present times, young students are learning these tools in schools and colleges in India. Many training institutes have mushroomed to coach students with these skills. The skill demand for BIM has gone up manifold and this has given rise to various skill level certifications. Technology vendors are also offering certifications with their tools to encourage adoption.

4 Laying the bricks of BIM from 2008 to 2022 (as experienced by Excelize)

4.1 Phase 1: 2008

4.1.1 Mumbai airport: April 2008–December 2014

The Background:

The construction of Mumbai airport T2 was a mega project, the building being spread over an area of 5 million sq ft. The complex design and coordination was done in 2D and the confidence of the team about the quality of the output was remarkable (Fig. 8).

The Excelize team was entrusted with the challenge of showcasing the benefits of BIM adoption for coordination. A Proof-Of-Concept (POC) was conducted for an area of 5000 sq ft. before the work on the entire terminal was done.

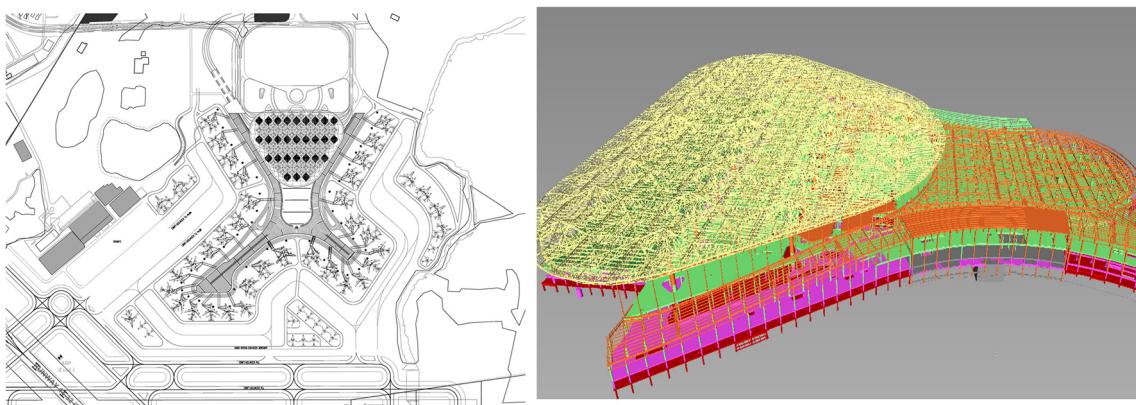


Fig. 8 Image from BIM model (Mumbai Airport)

Observations:

- The 2D drawings provided as input had missing information for building the model. If these were used for construction, there would be multiple Request for Information's (RFI) generated, it would require a lot of rework at site, decisions would have to be made on the spot which would not be recorded.
- When clash detection was done through the BIM model, the results astounded all concerned project stakeholders. Coordinated drawings should not have any clashes but the reality was opposite. This was an eye opener for the Design Build (D/B) contractor to adopt BIM for the entire project.
- No BEP was generated, no standards were setup, only BIM goal was to generate coordinated 2D drawings from clash free models. The contract was a means to agree regarding the scope of work and deliverables.

Project Approach:

- Excelize team worked off site and built the model, performed clash detection. Rules for clash resolution were determined by the individuals working on the project. Every designer had his/her perspective for resolution. Excelize team then took initiative to document the rules that could be shared with the teams, and this led to the first piece of standardization.
- A team was deputed on-site for almost 15 months along with hardware/software. This team worked with the design team to resolve the clashes.
- Thereafter, the value engineering exercise was conducted with the involvement of site team, which involved re-design and second round of clash resolution.

Challenges:

- Clash free areas and models were produced which the contractors' team was not capable of viewing. Lack of

trained staff, infrastructure (hardware/software) and resistance to accept change were some of the barriers to implementation.

Outcome:

At the end of this phase, walkthroughs were generated from the model which the team used for inspection during installation.

4.1.2 A leading group of hotels: Feb 2012–May 2012

The Background:

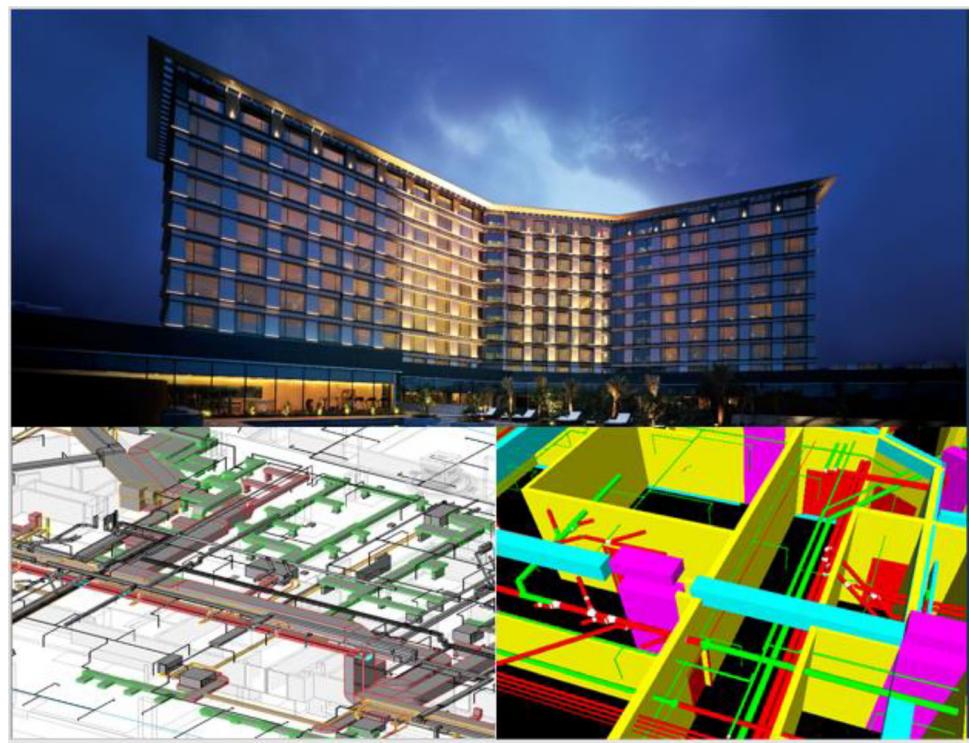
Team Excelize demonstrated the value of BIM models through a presentation. The ability to visualize the entire space in 3D, to plan the services routing more efficiently, identify clashes early in the design process and how all of this supports the onsite team during the installation process (Fig. 9).

Observations:

- No training was imparted to the team for deploying BIM. No infrastructure was provided for exploration of BIM. There were no instructions given to use the information generated from the model in place.
- The team on site was reluctant to examine the BIM models and extract the information available therein. The onsite co-ordinator was encouraged to step out of the comfort zone and look at the BIM models along with different site team members.
- Information in drawings was incomplete, so, models had to be made based on certain assumptions.
- Design consultants were not keen to take decisions on resolving all clashes as they assumed that it was in the scope of subcontractor's work.
- Focused co-ordination meetings weren't organized for initial review of the models.

Project approach:

Fig. 9 Images from BIM model and rendering (Leading Group of Hotels)



- Excelize worked remotely on building the model, had a part time BIM coordinator driving the in-person meeting & getting clashes resolved
- After one-on-one meetings with different team members, there was a gradual shift in their approach towards viewing the model. A bottom-up approach worked in realizing the value of BIM models.
- Walkthroughs that the Excelize team organized for critical areas, were used by some subcontractors during installation.

Challenges:

The client team was comfortable with their traditional approach of design co-ordination and had been rather reluctant to change. It was incredibly difficult to convince them in favor of BIM adoption. In the absence of any contract that identified the deliverable, the scope of work was unclear and insufficiently defined. From the client's end, there was no team identified to review and utilize the information that would be shared by the BIM team. An existing project manager was assigned an additional responsibility of assisting us, adding to his burden. The project site was in Bangalore and the client was not equipped to view models, so Excelize had to appoint a coordinator to visit them at site, who would view and refer to the BIM model.

Outcome:

As the project was on the verge of completion, there was openness to using BIM during construction as a

coordination and visualization tool and sought appreciation by team members.

4.2 Phase 2: 2014–2018

Several real estate developers were adopting BIM during this period. Challenges with this were that they did not have the right approach and strategy to make BIM implementation a success. Many first projects were carried out, but they couldn't integrate BIM wholly and sustain momentum.

4.2.1 JIO world: 2014

The Background:

BIM Modelling services were sought by a leading telecom giant for the construction of international exhibition and convention center. Request for Proposal (RFP) was floated and 2 bids were received. An interesting enhancement in the evaluation criteria was the emphasis on prior work experience, over being just restricted to commercials. The principal contractor—Samsung Korea—was appointed to evaluate the process. They visited the Excelize office, reviewed the company's processes, quality audit protocols, team capabilities and even the license compliance for the BIM tools to be used in the project (Fig. 10).

Observations:

- This project coordination would have been a massive challenge if BIM was not deployed.
- Roles and responsibilities of all stakeholders were clearly defined when related to BIM implementation
- Hybrid model of on-site and off-site team helped during the initial stages with overcoming the reluctance for remote coordination
- Principal contractors used the model for construction sequencing and planning

Project Approach:

- The modeling approach was a hybrid one:
 - Design models were provided by foreign design consultants
 - During the construction phase, the BIM team was asked to build the architectural and structural models.
 - MEPF (Mechanical, Electrical, Plumbing Fixtures) consultants were to build their own models.
- On-site team was to work for 1 year from the site office once the LOD 300 model was built.
This team was responsible for coordination with contractor's team
- The principal contractor was responsible for the construction planning and simulation of design.
- This was the first project that had a requirement for an as-built model along with asset tagging
- Within 3 months of starting work, MEPF consultant withdrew themselves from the BIM scope (they lacked the skill and team size) and Excelize team was appointed for this task as well.
Along with clash resolution, value engineering was also being done by the design consultants



Fig. 10 Design rendering of JIO world

Challenges:

- A large-scale project which involved multiple activities at same time, managing these activities was challenging.
- Project need was to work with big team and resources for meeting the project timelines managing the big team was a challenging task.
- Onsite and offsite team were involved in coordination and implementation the coordination between the team was challenging
- This was unique and one of the biggest projects with mixed use design, multiple designers and consultants were involved in the project. To get timely resolution from the consultant was the biggest challenge for coordination.

Outcomes:

- Owners team should appoint a BIM champion to drive BIM modelling and allied services. It cannot be done through the contractor as they do not have the complete view of the project.
- Asset strategy should be thought and formulated early in the lifecycle as this affects the LOD of the model
- 4D construction simulation was done but was not used for catch-up planning.
- Models built were not used at coordination meetings but only the clash report was reviewed.

4.2.2 Campus for a large IT services company: 2015

The Background

TCS, an IT giant required BIM support for setting up 10 campuses at 4 locations: Bhubaneshwar, Thiruvananthapuram, Nagpur, and Mumbai. There were 2 BIM consultants working on this project and hence, it was mandatory for the project team to setup standards. No BIM execution plan was set up for these projects though.

The Request for Proposal (RFP) had a very clear scope of work identified and the deliverables were documented. A contract was drafted clearly stating these aspects. The work was done by the concerned BIM consultants for various campuses (Fig. 11).

Observations:

- Most of the issues stemmed from the top-down approach. No time was given to site teams to adopt and evolve through processes.
- Contracts made with the contractor had not specified BIM verification which created tremendous resistance at the contractor's end.
- Owners kept tweaking the design even while the construction was being done, so many changes had to be incorporated in real-time.

Fig. 11 Image from BIM model

Project approach:

The scope extended itself beyond BIM modeling for clash detection and coordination, as laid out in the contract. It included:

- BIM model for architecture, structure, services, site, landscape, site utilities, interior fixed furniture
- Extracting Bill of Quantities (BOQ) from clash free design model
- Bill verification for the BOQ from model and contractor's Running Account (RA) bills
- The planned schedule for execution was linked to the model at the commencement of the project. During construction, the schedule might undergo changes and using the model, the planned schedule could be simulated. This helped mark out the activities that are delayed or behind schedule and highlight the areas which are on time. This is possible with 4D BIM.
- Dashboards and reporting to management
- Appointment of on-site BIM coordinator

Challenges:

- The design was evolving as the construction was progressing at site. The design coordination had to be repeated with every change and this affected the Mechanical, Engineering, Plumbing (MEP) design.
- BIM models were not used to generate the 2D. It was a 2D to 3D effort, which was the reverse of the usual approach which made it more cumbersome.
- The material specifications were not always available to generate the BOQ from the model for all items
- Site changes on materials resulted in consumed quantity not matching tender quantity or BIM quantity as estimated in the plan (specifications had M30 grade concrete and so did the BIM model. Site team

substituted with M35 which resulted in quantity mismatch).

- Transparency that the BIM model brought was not accepted by the contractor as all information related to materials was clearly visible to all team members.
- On-site coordinator took around 6–7 months to feel included as a part of the team.

Outcome:

The adoption on the first project was a failure and as BIM consultants, Excelize team faced push back from everyone. By the time, the team started work on the third location, the acceptance had increased manifold.

4.3 Phase 3: 2017–2018

New airports being built in India have RFPs asking for BIM Modelling services for design coordination and extraction of quantities.

The Background:

Civil Aviation is the fastest growing arm of India's transport infrastructure, and it plays an increasingly important role in providing connectivity. The projections for both passenger & cargo traffic growth, coupled with the deficient & lagging airport & allied infrastructure, calls for an urgent need to build & augment India's Aviation Infrastructure.

Recently the Prime Minister of India has launched India's biggest international airport at Jewar which will help in decongestion of Delhi's IGI, which spreads over more than 1300 hectares of land, the completed first phase of the airport will have a capacity to serve around 1.2 crore passengers a year and work on it is scheduled to be completed by 2024, costing Rs 10,050 Cr. Similarly, there are many International and Domestic projects coming up and

are ready to execute the projects using BIM for faster deliveries along with other benefits of BIM. Hence asking BIM services related to 3D Models, coordination, and clash free drawings.

Scope of Work:

The scope could be as below,

- BIM model for architecture, structure, services, baggage handling, landside and airside services, site, landscape, site utilities, interior fixed furniture
- Extracting Bill of Quantities (BOQ) from clash free design model
- Bill verification for the BOQ from model
- 4D construction simulation
- 5D Cost Management
- CAD 2D output drawing from clash free Models
- Asset Lifecycle Information Management
- Dashboards and reporting to management
- On-site BIM coordinators

Challenges:

The client's team is generally accustomed to their usual approach of design coordination and hesitant to alter. It becomes harder to convince them to adopt BIM.

4.4 Phase 4: 2020–2022

4.4.1 Nagpur Metro: 2016–Ongoing

At Nagpur Metro, now MAHA Metro, a 5D BIM digital platform has been implemented since 2015. 5D BIM also referred to as five-dimensional building information modelling enables extraction or production of fully valued invariable project constituents via a virtual model.

The traditional approach followed in the construction industry often struggles to deliver the project on time and within budget. Lack of precision and exactness in the process of information flow lead to conflicts between stakeholders. Inability to understand and interpret 2D drawings often leads to reduction in productivity, more chances of defects resulting in rework, wastage of resources, extra cost and time. Design management, document control, quality assurance, timely completion, cost control, risk mitigation, maintaining safe construction environment and effective operation and maintenance of services are among the most common challenges faced by the construction industry. Reduced rework, reduced coordination problems, better communication between various stakeholders, reduced documentation errors, fewer claims, reduced paperwork, reduction in time and cost overrun, reduction in lifecycle costs are amongst the main benefits of 5D BIM.

The results show that 5D BIM based digital project management system integrates all the processes, improving

the efficiency and effectiveness of the project, right from design through operation and maintenance (Fig. 12).

4.5 Mixed use – Retail/Commercial/Residential: Feb 2022

The Background:

- This is a mixed-use retail center situated in Mumbai. BIM has been mandated by the developers for all the projects they are working on pan India.
- RFP was generated, bids were invited, and the portal was used to submit bids.
- The RFP mentioned that a design model will be provided by the developers. This was an example which demonstrated that there were no barriers to adoption, design had started with 3D, BIM standards were available, and goals have been clearly laid out.

Observations:

- Architect and MEPF consultants on this project are building their own models. The BIM team at Excelize is only building structural models. The architects have setup CDE and are driving the entire workflow.
- Bids had to be submitted with prior experience documents, reference check contacts, approach and methodology for this project, team profile, confirmation on capability of using CDE (Common Data Environment)
- Technical evaluation was done through presentations and discussion with the client's team.

Project Approach:

The scope extended itself beyond BIM modeling, as laid out in the contract. It included:

- Architectural base BIM model
- BIM model for structure.

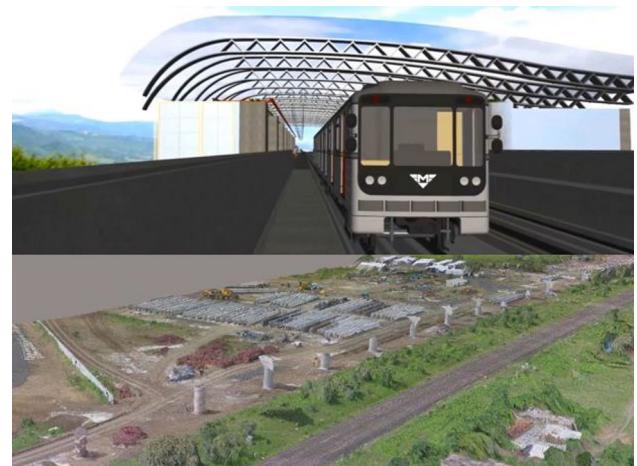


Fig. 12 Nagpur Metro

Fig. 13 The digital platform architecture

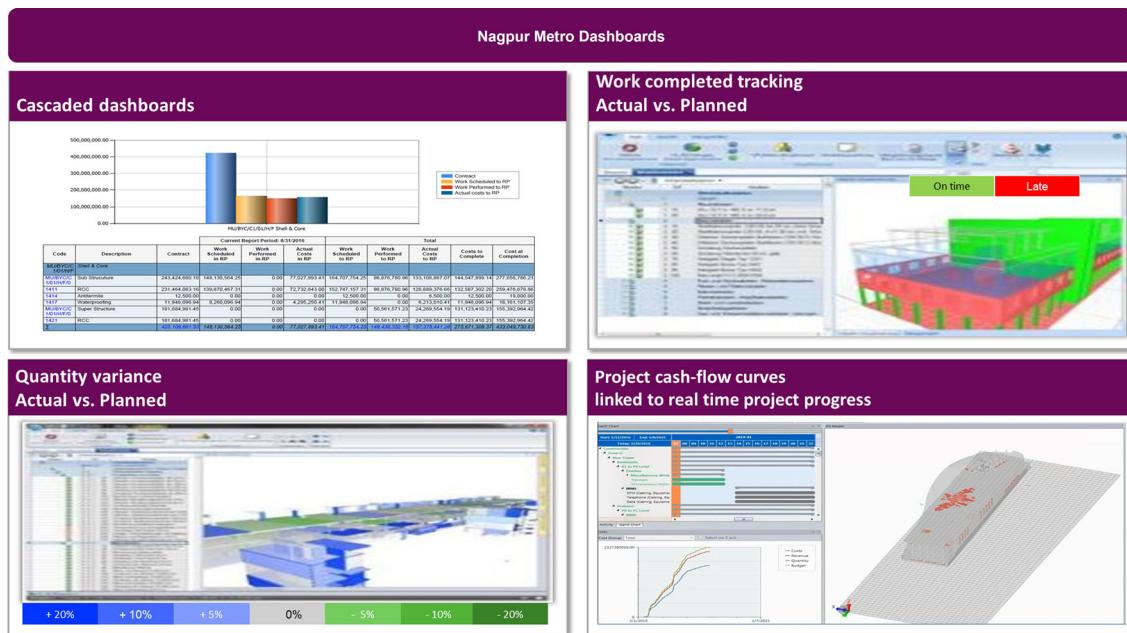
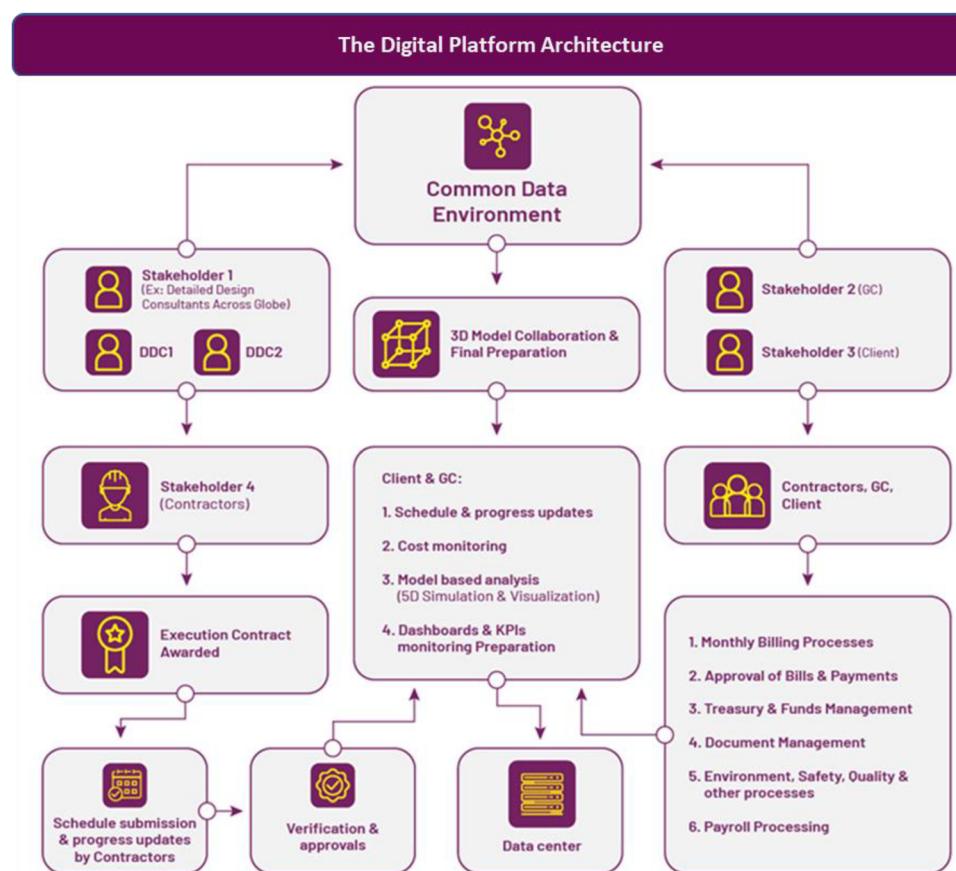


Fig. 14 Nagpur Metro dashboards

- Extracting Bill of Quantities (BOQ) from clash free design model
- 2D GFC extraction for structural services.
- Construction simulation (4D), cost management (5D), asset model, Digital twin was identified as the scope.

Challenges:

During the technical presentation, the work done was showcased including an asset model. The team at Excelize did not know what the customer's definition of Digital Twins was. They weren't aware of what it would take for the BIM design team to create a digital twin. The BIM team then worked with the client's team and a technology supplier to educate them about what is involved in the process.

Outcome:

The client decided to implement Digital twin in phase 2 as the technology and process would have expectedly evolved as they reach this phase in 3–4 years.

In 2021–2022, Excelize moved further: the new RFP for BIAL (Bangalore airport) lists the following:

- Laser scanning the exiting airport terminal to generate an as-built BIM model
- Gathering all the asset data and integrating it into the model
- Using AR-VR technology (Augmented reality/Virtual reality)

Adoption of BIM is met with skepticism at multiple levels and from there, stems the myths.

- The implementation is capital intensive.
- BIM cannot be leveraged to its full potential if everyone in the organization does not adopt.
- Working with BIM consumes more time as compared to the traditional process
- Return on Investment (ROI) is not immediate.

Some other reasons which induce resistance towards BIM adoption:

- The degree of transparency after BIM implementation is very high. Visibility of detailed information through the models at every stage of the project makes certain contracts rather uncomfortable.
- BIM requires a lot of details to be integrated during the design process itself, which is typically done later in the traditional method.
- There's an assumption that very little utilization of the BIM model happens in the construction phase

5 The success mantra: 5D BIM

Maha Metro is the first organization in the country to implement 5D BIM project visualization. 5D BIM is a digital project management concept that integrates many softwares seamlessly and employs 5D BIM to accurately predict outcomes and timelines. This unique system has enabled Maha Metro to control quality, cost and time rather tightly.

The Maha Metro project has achieved construction excellence, first converting future physical works into a prior virtual reality and then re-transporting it to the reality of the physical work. Such an amalgamation of convergence of physical and virtual reality in project management is unprecedented in the country, either in government or the corporate sector.

In a country where large infrastructure projects have gained notoriety for time and cost overruns and have often delivered dubious quality, using the new 5D project management platform, Nagpur Metro has broken from the traditional vicious circle of project management and delivered consistent quality along with timebound completion. Furthermore, it has impacted a saving of 10 per cent over the estimated cost as provided in the Detailed Project Report (DPR) (Fig. 13).

Nagpur metro was the first 5D BIM implementation project in India. This project has certainly paved the way for many such applications now. In the last 2 years (2020–2021) almost all public infrastructure projects are mandating BIM and its various dimensions to be digitally integrated with planning, construction management, cost monitoring, asset management and even digital twins (Fig. 14).

6 Conclusion

Construction industry in India is growing with growth in urbanization and a large number of the country's population depends on this industry. It also contributes to more than 5% of the country's GDP and the growth is exponential.

BIM implementation across the globe has evolved over a period of time and its numerous benefits have been observed and realized by industry participants. The purpose of the study was to understand, analyze and know the past, present and future of BIM implementation in India from the industry perspective. Excelize, BIM service provider in India, with close to two decades of experience in the AECO industry has studied, collated, analyzed, and put forth the industry perspective of BIM implementation in India.

An exhaustive database of the various projects, all allied information and data related to the projects handled and undertaken by Excelize through its years of practice has been thoroughly collated and analyzed. On the basis of which, we can conclude that the number of projects incorporating BIM have exponentially increased with a significant drop during the year 2020 and 2021, most likely because of COVID 19. Also, comparing project types which have used BIM, we see that maximum residential project and followed by commercial projects have used this tool (Fig. 5). It is seen that projects owners and/or developers have realized the benefits, with each passing year and more and more projects owners and/or developers are incorporating BIM for their projects. In the first half of the last decade, it is seen that Project owners/developers were more proactive in adopting BIM, in the middle of the decade (2015) it is seen that the maximum consultants were adopting BIM, however in the last 5 to 6 years, the Contractors spearhead significantly in adopting BIM for projects.

We can also conclude that a large number of partakers of the industry showed no interest in BIM at the start of the last decade, however with time the interest to know has increased. Also, in the last decade many have realized and confirm that it is a ‘must have’ tool for the several benefits BIM implementation has on a project and its success. Though number of projects using BIM has seen a drop in 2020 and 2021, the need to have the tool has been realized by the project participants extensively in the last 2 years of the pandemic. Curiosity on ‘what more can BIM do’ for a project has also seen a growth, an exceptionally high urge to know more is seen in last year.

From the experiences of Excelize in execution of projects using BIM from 2009 to 2021, the 3 phases in which the projects have been categorized we can see with every next phase there are more learnings, more explorations, more detailing, more analysis, more clarity, more understanding, more ease, better coordination, better visualization, better time management, better cost monitoring, better construction management, better asset management, and others. Thus, we can further conclude that BIM has several benefits for the overall success of a project and it’s well-being through its project life cycle. The layers to be explored by the project participants and BIM service providers are also many. BIM maturity in India is in the phase of rapid adoption, though the evolution faced and is still facing several challenges while being adopted. However, BIM is the future and way forward in the AECO industry. One should be embracing the power of virtual design and construction through BIM and ‘adding value’ to the projects and its participants.

6.1 The future of BIM

The Indian AECO industry has a long journey ahead both in terms of opportunities for growth and challenges in the areas of productivity, cost management, safety, sustainability and more! India is at the cusp of infrastructure development. India plans to spend USD 1.4 trillion on infrastructure between 2019 and 2023.

Looking at what lies ahead of us, it is our prerogative to ensure that projects are completed on time with the most efficient consumption of materials and resources. Sustainability consideration will also need to be an integral part of all construction projects. We, at Excelize, believe that technology will be a key enabler in making this possible. It has the potential to transform the way we build and construct. With the evolving needs of construction projects in India, technologies like Internet of Things (IoT) & Object Recognition, from energy modelling on the fly to prefabrication of building systems, these potential advancements are game changers for AECO firms. BIM, ERP, Virtual Reality, etc. are a collection of path-breaking platforms, tools and technologies that can change the way the construction & Infrastructure industry operates, evolves and executes.

BIM is the first building block for making the integration of a series of technologies possible. Artificial Intelligence, Green Energy, Cyber Security, LIDAR technologies and more could all thrive with BIM as the building block. BIM implementation across the globe has evolved over a period and its numerous benefits have been observed and realized by industry participants. It is also interesting to note that the threshold kept shifting upwards and forwards with regard to BIM benefits. Teams moved to higher clarity, increase in depth of information through modelling, better visualization, improved project coordination, more efficient monitoring of construction schedules, better cost management, well-laid out asset management. So, it is fair to say that BIM maturity in India is at the cusp of manifold growth, though there are several challenges that need to be addressed.

AECO firms, project owners, contractors and architects should collaborate to deploy BIM in its full spectrum (from 3D to 8D). For most projects, it will take just 1% of the project cost to accrue intangible benefits like timely procurement of materials, timely completion of projects, predictable payment schedule for suppliers and more.

Therefore, AECO project owners are recommended to actively address the barriers to BIM adoption, initiate a culture of BIM-based design thinking and project implementation, equip teams with the requisite skills, learn from best practices and BIM standards around the world and if possible, mandate BIM at an organization or project level. Embracing BIM will certainly accelerate project

implementation and create new benchmarks in quality, safety and sustainability for India's AECO industry.

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