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Seminar on

"COMMON DATA ENVIRONMENT FOR INFRASTRUCTURE PROJECT MANAGEMENT"

January 28-29, 2023
Bhopal (M.P.)

आधुनिक तकनीक सुरक्षित निर्माण
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Mid-Term Session
and
National Seminar on

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FOREWORD

A construction project supported by information technology can lead to better timeline, proper Management of budget and great reduction in errors during its execution. Common Data Environment provides the way to deal with the problem of inaccuracies in adoption of data by creating a single source of sharing the construction data among various stakeholders. This also provides collaborative way of working which is necessary for successful completion of a infrastructure Project.

A building before its construction, if conceived virtually may help greatly in visualizing problems in its planning, designing, construction, co-ordination and other related facets clearly. Information technology through building information modeling has helped building planners, architects, engineers to understand and prevent these problems before- hand and provided a plausible solution.

The centralization of data storage within the Common Data Environment (CDE) reduces the risk of data redundancy and ensures the availability of up-to-date data at any time. Furthermore, the CDE leads to a higher rate of reusability of information, simplifies the aggregation of model information and simultaneously serves as a central archive for documentation. Since this environment is accessible for all the project participants, it should be used as a platform for Building Information Modeling (BIM) based collaborative processes.

To obviate the problem of effective communication and to take the project progressively in the right direction, the timely communication of undistorted tremendous amount of digital data required during construction to various stakeholders involved in the project is the pre-requisite. This will enable the system to send the timely alert to the stake holders for getting ready for their part of action in the project. For flawless implementation, the data should convey same meaning or interpretation to each stakeholder within the project team. .

Perhaps there is need for making a concerted movement for making Common data environment for infrastructure management a mandatory requirement for all the major construction projects so as to reduce time and cost over-run, achieve higher efficiency and performance through real time effective communication and monitoring.

Various technological breakthroughs in formulation of CDE for managing the infrastructure projects would be deliberated during the two daylong Seminar. It is felt that the subject being very much relevant in the present day context of infrastructure management, would generate interest amongst the delegates and professionals alike and this Seminar will come up with useful recommendations for the construction industry opening up new vistas for improvements.

(V.S.Verma)
President, IBC

PREFACE

Architects, designers and engineers are now involved in planning, designing, execution and maintenance of high rise structures having multiple services keeping aesthetic, functional and green building requirements in consideration.

Due to large infrastructure development, construction industry has also grown in scale and architects, engineers and construction companies have to expand their operations on global basis. Global competitiveness has further brought innovations and complexities in designs of the structures involving large amount of data. Operation and maintenance of complex structures has also become a specialized field hence storage of data has to be preserved in a way that they are available as and when required. Thus, stakeholders involved in planning, construction and maintenance process have to be consider these factors during planning, designing, execution and managing projects optimizing cost and lifecycle maintenance.

Thus, modern projects require better planning, design and robust project management considering life cycle management to achieve the objective of optimum cost and timely completion of the projects. This needs use of digital technologies and data management. CDE-BIM modelling is going to provide the way forward. Artificial Intelligence (AI) will further support CDE-BIM in future.

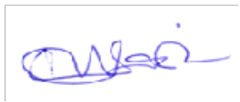
Construction projects have enormous data generated from conception stage onwards including planning, execution and post-construction and thereafter till completion of their useful life even during demolition stage. Therefore, data related to the project have to be stored in an appropriate structured manner for the utilization. This can be done through common data environment (CDE) platform. Thus, CDE-BIM is going to be very useful even though being used in a very limited level today.

Even though CDE-BIM is useful in all projects, it can be used initially in major projects involving large services. In future, Artificial Neural Networks can also be used to predict cost overruns based on factors such as project size, contract type and the competence level of the project managers. In future, CDE accompanied by AI can aid the design process with the use of generative design to produce many alternative designs.

AI with the help of CDE and BIM is changing construction by providing a steady flow of relevant data. When used in BIM, data can be shared with all stakeholders involved in the process to represent the insights visually on dashboard.CDE-BIM also helps construction Project managers to improve the waste management and cost-efficiency.

Considering the growing infrastructure in the country, the topic of "Common Data Environment for Infrastructure Project Management" is very relevant to the present day demand. The topic has evoked a keen response from the authors, and accordingly 14 papers have been selected for publication and deliberation as per the availability of time during the National Seminar being held at Bhopal. All the relevant issues pertaining to data handling and BIM will be deliberated at length in the National Seminar. I hope the deliberation in the National Seminar will bring out useful recommendations for gainful utilisation by the stake holders in the construction industry.

I express my sincere thanks to my colleagues Ms Usha Batra, Mr C S Mital and Mr. V R Bansal in the Technical Committee for their valuable support in screening and selection of the papers. I also acknowledge the efforts of Shri M.C. Bansal, Advisor (Tech.), IBC and Shri N.K. Singh, Dy. Secretary (Tech.), IBC in bringing out this publication.



(Dr. K.M.Soni)

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CONTENTS

"COMMON DATA ENVIRONMENT FOR INFRASTRUCTURE PROJECT MANAGEMENT"

PM GATISHAKTI NATIONAL MASTER PLAN

S. BHARDWAJ*

Abstract

The PMGS is a transformative approach. It enables a mechanism for coordinated planning and to provide a bird's eye view of planned development to all the Central Govt. Ministries and State Govt Departments for a holistic and integrated development by eliminating silos.

PMGS will leverage technology extensively including spatial planning tools with ISRO imagery developed by BiSAG-N (Bhaskaracharya National Institute for Space Applications and Geoinformatics).

INTRODUCTION

The "Prime Minister GatiShakti National Master Plan" (PMGS-NMP) was launched by Hon'ble Prime Minister on 13th October, 2021 with a vision to break Departmental silos in Government and institutionalize holistic planning for stakeholders across major infrastructure projects. All departments now have visibility of each others projects through a centralized portal. The multi-modal connectivity provides integrated and seamless connectivity for movement of people, goods and services across the country. In addition, PM GatiShakti shall generate multiple employment opportunities, cut down logistics cost, increase logistics efficiency, improve supply chains and make local goods globally competitive.

PM GatiShakti will address the past issues through institutionalizing holistic planning for stakeholders for major infrastructure projects. Instead of planning & designing separately in silos, the projects are now being designed and executed with a common vision. PMGS incorporates the infrastructure schemes of various Ministries and State Governments like Bharatmala, Sagarmala, Inland Waterways, dry/ land ports, UDAN etc. Economic Zones like textile clusters, pharmaceutical clusters, defence corridors, electronic parks, industrial corridors, fishing clusters, agri zones are being covered to improve connectivity & make Indian businesses more competitive.

**DDG, DPIIT, M/o Commerce & Industry, GOI*

PILLARS OF PM GATISHAKTI

PM GatiShakti is based on six pillars:

- **Comprehensiveness:** It includes all the existing and planned initiatives of various Ministries and departments with one centralized portal. Each and every department now has visibility of each other's activities providing critical data while planning & execution of projects in a comprehensive manner.
- **Prioritization:** Through this, different departments are able to prioritize their projects through cross–sectoral interactions.
- **Optimization:** The National Master Plan assists different ministries in planning for projects after identification of critical gaps. For the transportation of the goods from one place to another, the plan helps in selecting the most optimum route in terms of time and cost.
- **Synchronization:** Individual Ministries and Departments often work in silos. There is lack of coordination in planning and implementation of the project resulting in delays. PM GatiShakti has helped in synchronizing the activities of each Department, as well as of different layers of governance, in a holistic manner by ensuring coordination of work between them.
- **Analytical:** The plan provides entire data at one place with GIS based spatial planning and

analytical tools having 200+ layers, enabling better visibility to the executing agency.

- **Dynamic:** All Ministries and Departments are able to visualize, review and monitor the progress of cross-sectoral projects, through the GIS platform, as the satellite imagery will give on-ground progress periodically and progress of the projects will be updated on a regular basis on the portal. It has helped in identifying the vital interventions for enhancing and updating the master plan.

PM GatiShakti is a Next Generation Infrastructure which improves Ease of Living as well as Ease of Doing Business. The multi-modal connectivity will provide integrated and seamless connectivity for movement of people, goods and services from one mode of transport to another. It will facilitate the last mile connectivity of infrastructure and also reduce travel time for people. It will create multiple employment opportunities and give a boost to the economy. It will improve the global competitiveness of local products by cutting down the logistics costs and improving the supply chains, and also ensure proper linkages for local industry & consumers.

EXPECTED OUTCOMES

The NMP platform will provide an integrated platform where all the economic zones and their connectivity infrastructures will be mapped. It will be necessary to boost the economic and overall development of the region. The same will provide physical linkages to promote comprehensive and integrated multimodal national network of transportation and logistics thereby enabling smooth transportation of goods, people and services to create efficiency gains and avenues for further developments, value addition and creating employment opportunities. Any State Government/ Central Ministry/ PSUs, before planning any investment in any economic zone like textile park, fishing cluster, agro-processing centres etc. can know beforehand the status of current multimodal connectivity like proximity to highways, airports, rail, ports, etc. This will enable the concerned planning/ implementing agencies to make informed decisions. On the other hand, infrastructure Central Ministries will be able to plan and prioritize connectivity enhancement projects for ensuring first-mile and last-mile connectivity in a time-bound manner.

BENEFITS

The PM GatiShakti NMP will provide accurate information and guidance for the completion of the Government's projects within the stipulated time-frame. It will also provide an analytical and decision-making tool to the stakeholders involved in the policy making of the country. This will help Governments in drawing effective plans and policies, keeping in view its priorities, thereby cutting down unnecessary Government expenditure. When such a data-based mechanism is in place in the country, the State Governments will be able to make time-bound commitments to the investors resulting in a growing reputation of India globally, as a promising investment destination.

CONCLUSION

- All 36 States/UTs have been onboarded to use PM GatiShakti National Master Plan.
- More than 1600 data layers of concerned Central Ministries/Departments and States/ UTs have been uploaded on the National Master Plan.
- Individual portals with necessary data layers, customized tools and functionalities for all concerned Central Ministries and State Governments have been developed for regularly uploading and updating necessary data layers critical for infrastructure and logistics development.
- Continuous training and capacity building of officers being conducted in physical modes at BISAG-N
- Training courses are being offered to officers on the IGOT platform.

- National Logistics Policy (NLP) was launched by Hon'ble PM on 17th September, 2022 and currently 16 States have notified State Logistics Policies
- 12 Social Sector Ministries/Departments have been onboarded onto the PM GatiShakti NMP platform viz. Ministry of Housing of Urban Affairs, Department of School Education & Literacy, Department of Higher Education, Ministry of Tribal Affairs, Ministry of Panchayati Raj, Ministry of Health and Family Welfare, Ministry for Women and Child Development, Department of Sports, Ministry of Rural Development, Ministry of Culture, Department of Posts, & Department of Youth Affairs.

COMMON DATA ENVIRONMENT IN CONSTRUCTION

BRIJESH PARMAR* AND SHIVAM GUPTA**

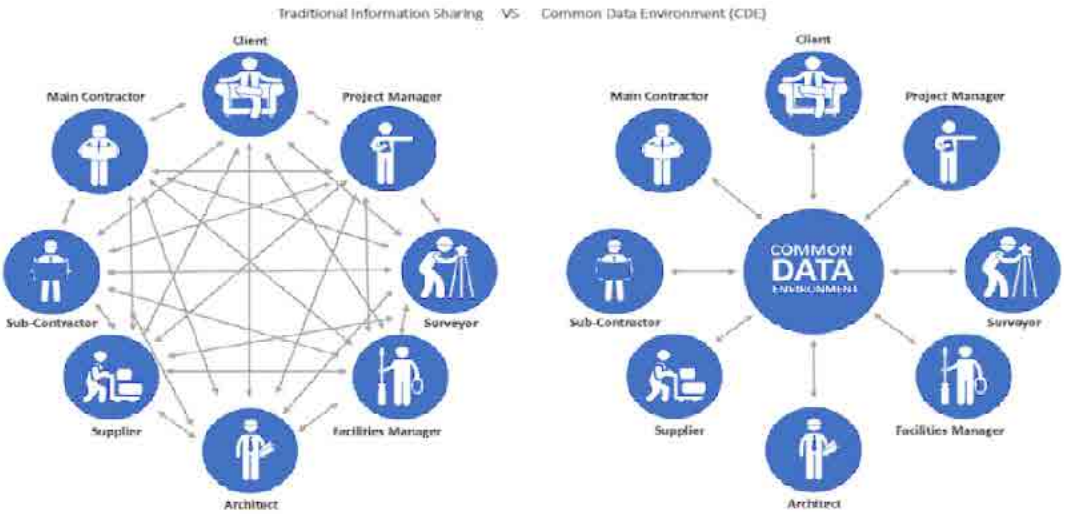
Abstract

It is quite evident that project/design management and optimization of management processes in Construction projects are a major challenge now-a-days. The goal of this paper is to present and discuss the possibilities which common data environment as technology brings in for the AEC industry. The paper showcases a widening technological gap between traditional AEC market practices and latest available technology due to lack of adaptability and awareness. The paper discusses how CDE becomes essential at different stages of project, right from capex planning of Project Information model to development of asset information model. The paper discusses the evolution of globally accepted CDE standards showcasing integration of both information and management processes over time. These global standards form the basis of typical CDE implementation structure for any Engineering & Construction Company. The paper also presents different CDE platforms in contemporary times and a comparative of their features in context of a developer & contractor. From this evaluation author shares the most appropriate type of CDE and its implementation strategies with an example of an on-going project.

INTRODUCTION

The rightful administration of construction projects is a complex and demanding process. Improper system controls result into increased project costs, project delays, reduced project quality, productivity and thereby revenue loss. The key to rightful administration is providing accurate and relevant information to those performing tasks or processes. With the project's growing complexity, it is challenging to fulfil this criteria. Large amounts of distinct data are created during building projects which are disorganized, unstructured, repetitive & unsecured.

A common data environment (CDE) resolves most of these problems as it is a digital information platform that centralizes & manages project data storage and access, connected to a construction



Source: Thesis, Seyed Emad Tabadkani

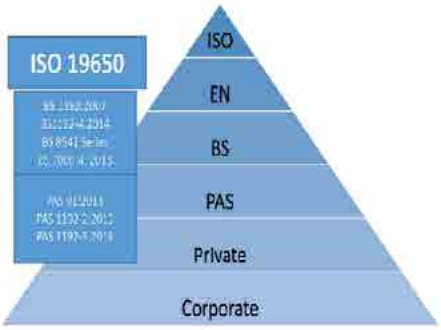
**General Manager (Architecture), Shapoorji Pallonji Company Pvt. Ltd.; ** Sr. Manager (Architecture), Shapoorji Pallonji Company Pvt. Ltd.*

project and also the building information modelling (BIM) workflows. Initially, BIM data and information made up the contents of a CDE. A CDE now also contains information about the design and construction phases of a project, such as contracts, estimates, reports, RFI's, field collaborative data, cost data and material specifications.

GLOBAL CDE STANDARDS

As the construction industry accepts new technology and expands BIM use, new protocols have been created to govern usage. The ISO 19650 is an international standard for lifecycle information management of a built asset using building information modelling (BIM) & CDE. It is closely related with the current BS 1192 standards and incorporates all the same fundamental ideas and high-level criteria as the BS BIM Framework.

BSI PAS 1192-2:2007are fast-track standards, specifications, codes of practise, or guidelines available in public domain created by sponsoring organisations in compliance with BSI requirements to satisfy an immediate market demand. They offer recommendations for BIM-enabled project information management. With the goal of reaching Level 2 BIM, which aims to create a lean, uniform project delivery process for use on any project, anywhere, regardless of any sector.

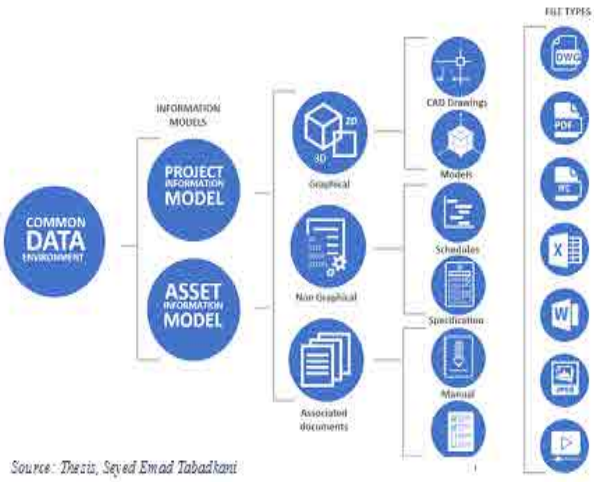


Source: Rani A Fattah- BIM Standards Hierarchy

PAS1192:2 The Process Brief

It adheres to the "information delivery cycle," a general procedure that begins with determining the needs of the project and concludes with handover. The following is a description of the PAS procedure in general terms:

1. Formulating EIR-Employer Information Requirement: Identifying a project's needs- Each set of Plain Language Questions (PLQs) in the EIRs is related to a particular project stage. The model's components provide answers to the queries at each level. By using this strategy, teams may prevent overproducing information by knowing what data is required for the models and when it is required.
2. Procurement and Contract Award: The EIRs may be distributed at this time along with the tender papers as a part of the selection procedure. A preliminary BIM Execution Plan (BEP) indicating how the EIRs will be satisfied is requested from the bidder. After contract award, the first BEP is again submitted with additional information verifying modelling responsibility. The BEP's goal is to explain how BIM will be used to complete the project.
3. Mobilisation: There is an opportunity for teams to test that the suggested approach works after contract award but before modelling begins. The activities might include creating a Common Data Environment (CDE), installing software and hardware, attending to training needs, performing interoperability tests, aligning the project documents, explaining the BEP to the team, and making sure the project team is aware of their responsibilities.

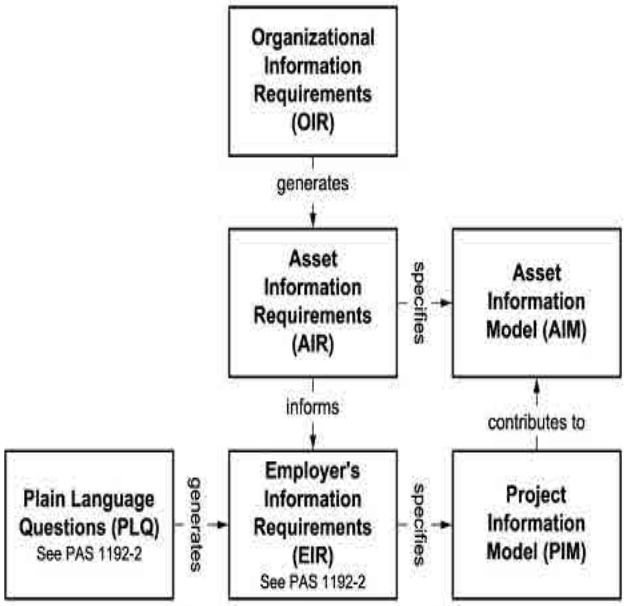


Source: Thesis, Seyed Emad Tabadkani

4. According to the BEP, the Project Information Model (PIM) is produced gradually, and the project team's primary tasks may include:

- Using project templates, library data and assemblies.
- Reviewing and approving information before sharing on the CDE

- Adhering to file and work set naming guidelines
- Spatial coordination such as design reviews and clash checks
- Using place holders and volume allocation to produce customized items
- Creating models with enough data to respond to the PLQs for each project stage
- Information classification for cost and specification data.



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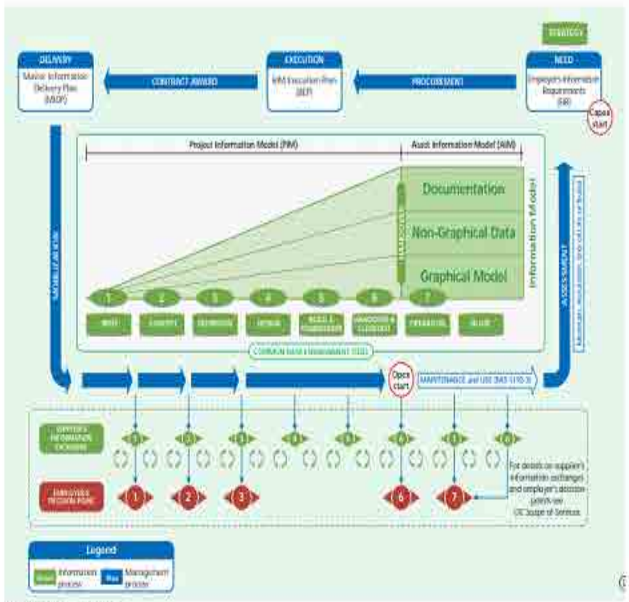


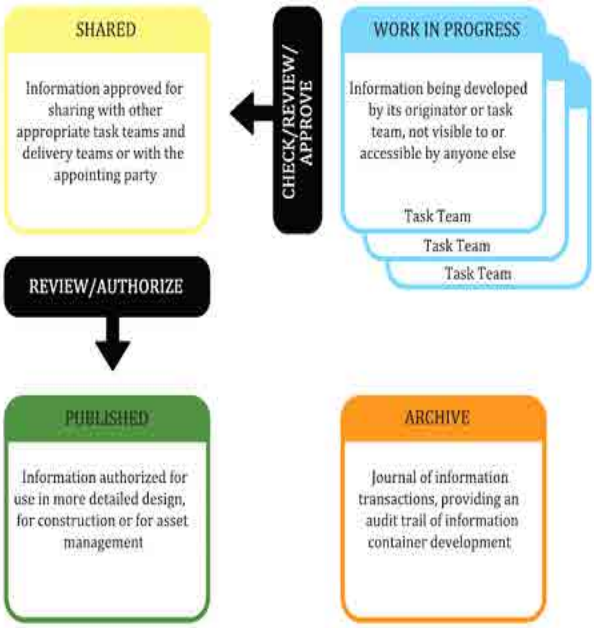
Source: PAS 1192-2

5. Asset Information Model (AIM): The information created by the project team during information production will be delivered at the end of this stage. The format of the material should follow that specified in the EIRs, which should be agreed upon at the project's outset.

The CDE's contents will consequently contain documentation, graphical models, and non-graphical assets as they are not restricted to assets produced in a "BIM environment."

CDE as per ISO 19650

The specific features that must be present on the relevant platform are determined by the specifications of a CDE as per ISO-19650. Having stated that, it has been determined which of the services provided by commercial platforms and their operations are compliant with the legislation as per ISO.



Source: ISO 19650-1 graphics

The following four phases of processing to be carried out by CDE platform as per ISO:

- **Work in Progress:** Area of the CDE where team carries out their own work using their organization's software systems. Non-verified design data used by in-house design team only.
- **Shared:** Area of the CDE where the team shares verified design data with other members of the project team.

- **Published:** Area of the CDE for coordination and validated design output for use by the total project team.
- **Archive:** Area of the CDE for project history maintained for knowledge and regulatory and legal requirements. It is also a repository of the project information for non-asset portfolio employers.

IMPORTANCE OF CDE IN CONSTRUCTION PROJECTS

- CDE acts as the single source of truth for all project data, serving as the project's core connecting point relied by all team members which is accessible anytime and anywhere.
- A CDE greatly lowers the possibility of losing crucial project data or getting modified as the project changes hands.
- It also allows for a Centralized working on a BIM model by different users across globe.
- It enables the team to review the RFI's collaboratively rather than working in traditional fragmented workflows, thus enabling better informed decisions.
- Well-structured CDE enables large construction firms to analyze the data efficiently, automate processes & dash boards enabling them to perform quicker and better

TYPICAL CDE IMPLEMENTATION STRUCTURE FOR AN ENGINEERING & CONSTRUCTION COMPANY

Based on understanding from standards following 3 are key points while designing a CDE implementation structure for a construction company.

- Organizing Project Data as per company standards and Workflow design for internal stakeholders with access planning.
- Establish processes for Submittals, RFI's and Change orders etc with external stakeholders.
- Real-time Collaboration on BIM Model amongst Project owners, Design Teams, Contractors & Site Team.

TOP CLOUD CDE PLATFORMS IN CONTEMPORARY TIMES

It's crucial to select a hardware and software architecture that offers the bare minimum capability required by code for an effective BIM information flow. As a result, a thorough study of the available commercial platforms was done to have an understanding as per the features requirement in the current market. Following platforms were chosen for study:

1. Auto-Desk BIM 360

It is a collaborative platform by Autodesk. It is a typical data environment for the construction industry that covers the complete building project life cycle, from design to maintenance. All the information is housed in a single cloud that can be accessed from mobile devices like smartphones and tablets. It is a single, centralised database for papers (even offline).

Through the use of specific permission management, the Team Administrator (BIM Manager or Project Manager) allocates roles and duties. The platform can manage two-dimensional data, 3D models, and other project documents, including IFC, PDF, and REVIT. The system enables you to use an internal viewer to examine the 3D model, add tables straight from them, and read all the characteristics of the elements from the Revit template file. In order to distinguish the properties within the cartouches and automatically populate information, the system also supports OCR functionalities. Comparisons between several Revit models and/or between pdf tables are possible with BIM 360 DOCS. You can annotate digital review or revision clouds (Markups and Issues) using annotation and revision software. You may also include hyperlinks. All submitted files must first have the reference manager's permission before they can be modified.

All project managers are automatically notified whenever you make a modification or submit new files. The system keeps track of revisions to various files and upload models, enabling comparisons across versions so that you can keep track of how the design is developing over

time. Models in the cloud may be immediately integrated using Autodesk's Revit programme. By utilising Desktop Connector, you may centralise documentation into a Common Data Environment and manage files associated with the Revit model within BIM360 DOCS.

2. Trimble Connect

Trimble Connect is a collaborative cloud platform that allows you to view, upload, and share all the files in a shared space. The platform may be accessed using desktop software, online browsers, mobile phones, and tablet computers. As a consequence of the many responsibilities allocated within the process, the project administrator establishes access rights to various areas of the platforms, or specific files and/or models. Additionally, it enables the assignment of team members and the generation of work lists.

You may upload 3D model files, 2D files, and documents in any format (such as PDF, DWG, DWF, and Revit formats) using the program. The system detects the attributes and related data for each imported 3D model element. Each 3D model may be searched and navigated.

Additionally, it is possible to contrast various papers that are being presented at once. Additionally, DWG files and models such as IFC may be layered.

Each component of the model can also have "attachments" connected to it, allowing you to search for the documents related to that component. You may specify the status and activity history for each generated action. Through messaging and notification features, the program facilitates communication between the many actors. Additionally, it provides the RFI function and report production.

3. Bim Sync

Bim Sync is a BIM collaboration tool with support for all of the building SMART standards (IFC, bSDD, BCF, COBie). It has several APIs for simple integration into your own applications.

By minimizing risk, boosting quality, and saving time, it enhances BIM cooperation. Nothing has to be installed; everything works in a browser. Information visualization is a key component of Bim Sync. To gain a complete overview of all the models in your projects, combine a high-performance 3D viewer with automatically created 2D floor plans. Map information can be streamed from other sources.

4. Asite

ASITE is a data-sharing platform on which you can read, upload, and modify files and documents. You may work from a computer, a mobile device, or even when offline. The administrator is responsible for defining the responsibilities of various individuals who have access to the platform. The platform interface may be modified to meet the user's demands. Any issues with the project may be reported by the administrator through comments. Various file types are supported by the platform (IFC, DWG, Excel, etc.). You may instantly import the 3D model using the Revit plug-in and see it on Asite. Pattern discrepancies may be found, modifications can be compared, and if verification is necessary, an email can be sent automatically to everyone involved in the project.

A site gives users the ability to report issues, classify them, and specify time limit with in which responsible designer has to resolve them. Users can be assigned to different workflows, which must be followed during the process and after the completion of each phase. You may compare and store every file version using Asite (versioning).

The software has a feature that lets you send email alerts anytime a document or piece of information is shared or altered, making it traceable. The system supports the integration of many software.

5. Aconex

Aconex is a cloud platform that connects the construction and engineering projects team. From the planning and feasibility stage through construction to the closure and delivery, it is a distinct platform that can be seen on the cloud and via mobile. IFC, BCF, and COBIE are used

to facilitate interoperability in Aconex, which is based on Open BIM standards. Each firm involved in a project can use Aconex to manage access to his personal data, maintain legal ownership, and establish sharing guidelines. A built-in viewer allows users to see the 3D BIM models online straight from the platform. A direct connection to an object in the project allows you to inquire about that object.

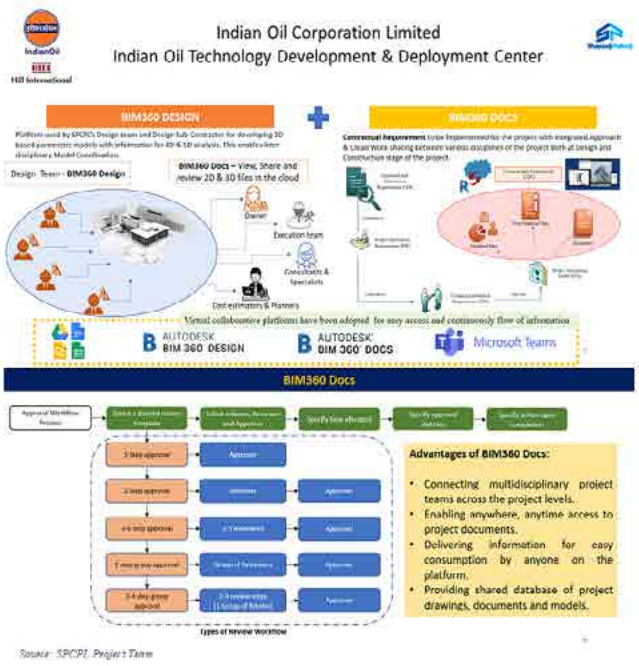
Project teams can upload the model's files and display, explore, and query the model in a customized manner. The system ensures traceability of all activities taken and keeps track of all file versions (versioning) (business history). It is possible to define the workflow, the deadlines for completing the various tasks, and the automatic cycles for review and approval. Real-time analysis is provided through the monitoring and reporting processes to identify and manage criticalities. Additionally, there is an online archive. You may access predefined reports to get an up-to-date and comprehensive overview of the file revisions situation. Also, there is a chronological order to all correspondence that cannot be changed. There is also a project e-mail room available.

PROJECT SHOWCASE: IOCL FARIDABAD-R&D COMPLEX

1. Project Brief

Design and Construction of Indian Oil Technology Development and Deployment Center at Faridabad. The scope of Work was EPC of the Buildings, Laboratories with Associated Facilities such as HVAC System, Electrical Works, Solar Power System, Fire Alarm System, IBMS, Fire Fighting, WTP, ETP, STP, RO Plant; Cooling Tower, MEP system, Laboratories Casing Works, Pilot plants, Demo plants, Pipeline test Loops, Utility systems, Lift, CCTV, Access Control System, IP EPBAX, furniture, soft scaping, Hardscaping, Murals, road work, fly over, scoop etc. with all Civil, structural, architectural, Mechanical, Piping, Electrical, Instrumentation etc.

2. BIM Processes, Standards, and Workflow during different Stages



Source: SPCPL Project Team

3. Major Challenges & their Resolutions

- Incompatibility with Construction Partners and multiple Vendors and consultants working on different platforms
- Lack of expertise within the majority ofmembers of the team.
- Legal ramifications
- Cost of licenses, thereby limiting users and access

CONCLUSION

A well-utilized common data environment enhances a project's overall quality and efficiency. Choosing a CDE that allows you to do more than just store information is crucial given the amount of information, people, and processes that are constantly in motion on any significant construction project. To meet all requirements on schedule is difficult. If the Common Data Environment is properly specified, building projects should be more resistant to changes in the external environment (such as laws, technological advancements, and shifting attitudes of local landowners in the case of long-term projects).

Throughout the lifecycle of a project, a strong CDE can narrow the information gap for all stakeholders. The aforementioned common data environment satisfies the requirements of BIM maturity level 2. From the perspective of the project's owner (investor), the deployment of CDE improves its control functions, which has a final influence on lowering costs, raising quality (while maintaining all essential criteria), and shortening turnaround times.

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PROJECT DATA INTEGRATION AND INTERFACE USING COMMON DATA ENVIRONMENT IN A BIM ENABLED PROJECT EXPERIENCE ON ADOPTION AND BENEFITS - CASE STUDY

DR.SENTHILKUMAR VENKATACHALAM*

Abstract

A common data environment (CDE) for information sharing is the recent development in the Indian AEC sector which may need to be adopted widely to resolve the inherent adverse characteristics such as lower productivity, rework, delay, and overspending of the Indian Building Industry. The advent of Building Information Modeling (BIM) in the AEC sector necessitates the deployment of the CDE for improving the effectiveness of the BIM. There is a lack of understanding and research studies around the CDE in contrast with the BIM implementation-related studies around the world. Especially, the literature is lacking in understanding the influence of CDE adoption on institutional/ organizational climate while executing the project. Therefore, this study focuses on addressing the impact on various institutional aspects through activity theory as the lens. Using an action research approach, one of the green field campus development projects in India was studied to understand the interplay of information interfaces among various stakeholders through CDE adoption. The activity theory was used as a theoretical concept to illuminate and analyze the implementation issues of CDE. The findings show that CDE implementation undergoes a series of transformations due to the transformation of various elements of the organization and its change from the existing work practices. The study provides vital insights to practitioners to be aware that the CDE adoption could be localized while balancing the various elements of AEC activity systems mentioned in the activity theory. The paper's insights can help further the managers to be better prepared with the shaping up of work processes to adopt CDE in a manner useful for the project by enhancing the implementation of the CDE and BIM.

INTRODUCTION

Modern Construction projects are executed with multiple stakeholders having complex interfaces among each other. Also, during the delivery of the projects, millions and millions of project information are generated, shared, and stored for the future stages of any building project. However, there exists a lack of administration on those generated, shared, and stored data. The advent of information technology applications has solved the above issues to an extent but not completely, this results in recurring problems in the industry such as tempering or forging data, unused data, obsolete data in time of need, wastage of time in finding the correct and "up-to-date" data, rework when incorrect data is used, which further leads to material, labor, and time wastages (Hjelseth, 2010; Mayo and Issa, 2014; Wong and Fan, 2013; Zhang et al., 2022).

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On the other hand, there are issues with handling of the unstructured enormous amount of data stored in an information technology application which leads to the discouragement of technology adoption and encourages the adoption of traditional paper-based information exchange/ management among the project stakeholders (Whyte, 2019). Hence, structured information generation, storage, and retrieval play a major role in streamlining and management of the information flow among the project stakeholders. Building Information Modeling (BIM) as a tool to store project information in a structured way has been demonstrated and reported in many projects and research studies respectively. However, the model interoperability/ data interoperability among the various project stakeholders still becomes a challenge and makes information management a complex system. ISO 19650 (Parts 1 -5) has been a guiding beacon on information management in terms of

its generation, storage, retrieval, and interface among the stakeholders and project lifecycle stages. However, the socio-technical aspects of managing the above-said complex system need theoretical insights to enhance the speed of adoption.

BIM implementation is mandated around the globe by various countries. The inclusion of a Common Data Environment to encourage collaborative information sharing or otherwise federation of project data is the basic implementation mandate which will lead to level 2 of BIM adoption maturity (Mason, 2019). There are many ways through which BIM implementation is advocated, some significant and classical strategies include -1. Government mandate 2. Industry ecosystem 3. Peer competition. In all these strategies towards implementation, the system-level changes within the implementation ecosystem play a major role in its success (Vass and Gustavsson, 2017). This paper attempts to discuss the same. Many theories have been reported in the literature for explaining complex systems such as technology adoption (Davies and Harty 2013; Enegbuma et al. 2015; Gledson 2016; Son et al. 2015; Wu et al. 2016; Xu et al. 2014, Akintola et al., 2019). Among these, the activity theory proposed by Engestrom and Miettinen (1999), is suitable to explain the theoretical account of the constituent elements of complex systems and their interactions (Akintola et al., 2019). Hence, this paper aims to explain the experiences of the client organization on adopting CDE and BIM in public project delivery projects. This study has objectives to investigate the effect of CDE implementation on a public infrastructure project to which the author has access and can influence the system-level change. Accordingly, action research is found to be a suitable research methodology in which the researcher can address the practicality of the concept implementation (Azhar et al., 2010, Love et al., 2012). With this background, the following section explains the CDE Ecosystem, and its implementation aspects followed by an introduction to the case under study. The paper further explains the case study and its CDE and BIM implementation through the discussion of a theoretical lens using activity theory. The paper ends with results reporting the benefits realized in the case study by the CDE and BIM implementation and the challenges experienced.

COMMON DATA ENVIRONMENT ECOSYSTEMS AND ITS IMPLEMENTATION

BIM adoption is facilitated through the CDE ecosystem which offers a collaborative way of working on the project information with security-mindedness. CDE's workflow design needs the client's intent and the BIM execution plan to translate the same into a supporting ecosystem to adopt the BIM. It includes the modality through which the project collaboration and its workflow among the stakeholders are done. Thus, CDE encompasses a considerably larger scope than the model development coordination performed in BIM (Patacas et al., 2020). CDE acts as an enabler to achieve the envisaged BIM's applicability in terms of handling the project information throughout its lifecycle among various stakeholders involved in the project. The basic capability of any CDE system includes information storing, sharing, publishing, and archiving with appropriate information status, workflow, and user access restrictions along with all the metadata generated and stored such as the history of the information development and its status. With this introduction to the CDE, the following section outlines the information on the case under study.

OVERVIEW OF THE CASE STUDY

The case study is one of the green field campus development projects for an academic institution of national importance in India. Development and Management of project information are vital for this campus development project, as the lead time of full development is longer (around 10 to 20 years). Different agencies, at different stages of the project, will be responsible for creating and managing certain aspects or elements of the built environment infrastructure of the whole campus. However, the institute must manage, coordinate, process, and ascertain that the appropriate information is created, stored, and managed in an organized way. Hence, the institute envisaged embracing the digital way of modeling the information of its physical and infrastructure assets and managing it through appropriate means. Building Information Modelling

(BIM) was a natural choice to achieve the same, BIM is an assembly of different project information digitally stored with a help of a Common Data Environment (CDE). This includes "geometry", or graphical data, structured digital properties or attributes of information, or non-graphical data, and relevant "documentation" (stored as files).

With this background, the institute has developed its masterplan of the campus with the student capacity of 12000 by two of their appointed architectural firms. However, the campus master plan development is planned to be happened in a phased manner. To start with the first phase of its development, the institute is mandated to develop a portion of the master plan which could accommodate 1200 students. The institute appointed a federal executing agency as their PMC towards the execution of this phase of campus development. The design phase development had suffered with challenges on managing the generated project information. The design project was characterised with rework, revision, data loss, working with earlier versions etc before the author joined as the employee of the institute. The institute envisaged being an example to society and is determined to execute the rest of the project phases with minimal rework and lead time along with the executing agency (PMC) through appropriate technology.

A leading contractor is appointed for this Phase 1 project under EPC Mode 3 project delivery model. The project includes the construction of academic buildings including an administration building, department buildings, classroom complex, research complex and heavy machinery lab complex, hostel buildings including 1000 bedded hostel, dining hall, faculty housing blocks, staff housing and director's bungalow besides internal and external services related buildings such as substations, sewage treatment plant, water treatment plant, among others. The contract was initiated in the year 2019. The client has mandated the use of Common Data Environment (CDE) in the campus development project as a first step towards enhancing the BIM use. Another motivation for using CDE is that it is much easier and intuitive, with minimal training required for the team for getting started as compared to other BIM tools and systems. The project has diverse project teams, namely architecture, structure, landscape, plumbing, electrical, and mechanical. Besides, the client engaged a third-party quality assurance service to assist in the monitoring of day-to-day activities to ensure compliance.In order to implement the CDE and BIM the project team would like to explore the implementation strategies which includes the analysis of existing work activity system of the project through activity theory, which is explained in the following section.

USE OF ACTIVITY THEORY AS THE LENS TO STRATEGIZE THE IMPLEMENTATION OF CDE AND BIM

To suitably conceptualise and clarify the nature of collaborative work practices among the project eco systems which includes the BIM and CDE in the delivery process, it is useful to employ the use of activity theory (Engestrom 1999, 2000). According to Engestrom (2000), any work activity system comprises of individual workers, tools they use to facilitate their work, rules that guide how they work, the purpose to which members of the workplace community direct their actions and the distribution of responsibilities between all the actors within the system as depicted in Figure 1. The inter-relationships among this work activity system elements may lead to translate the activity system in response to the climate it is attached with. These includes the enquiry proposed by Mwanza (2002) viz, what sort of activity of interest? To what endeavour do actors direct their efforts? Who is involved in carrying out the activity? By what means are the subjects achieving the objectives? What norms and rules govern the performance of the

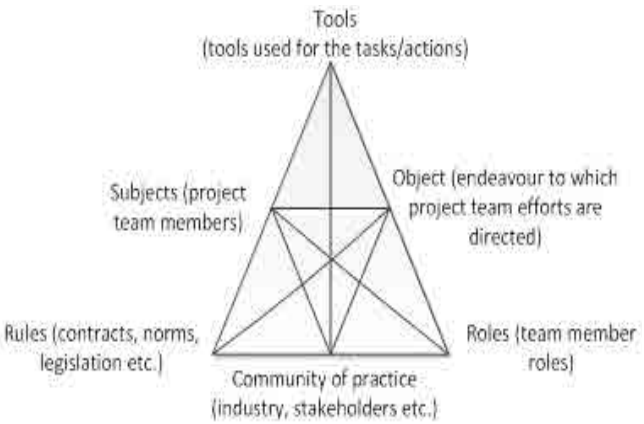

Fig. 1: Activity System showing the relationship between elements, Engestrom (2000)

responsible for what when carrying out the activity? What is the environment in which the activity is carried out? What is the desired outcome from this activity?

The existing climate of the project organizations are scrutinized to identify the potential translation of the activity system towards the digital transformation exercise initiated for this project. Discussions were initiated by the institutes on the implementation of CDE and BIM with architectural and executing agency (PMC). There was initial resistance from the stakeholders for the proposed digital transformation, as the organizational rules and policies of the public executing agency who are the PMC of this project conflicts with the proposed BIM and CDE implementation protocol. Fig. 2 depicts the project context activity system for the campus development project.

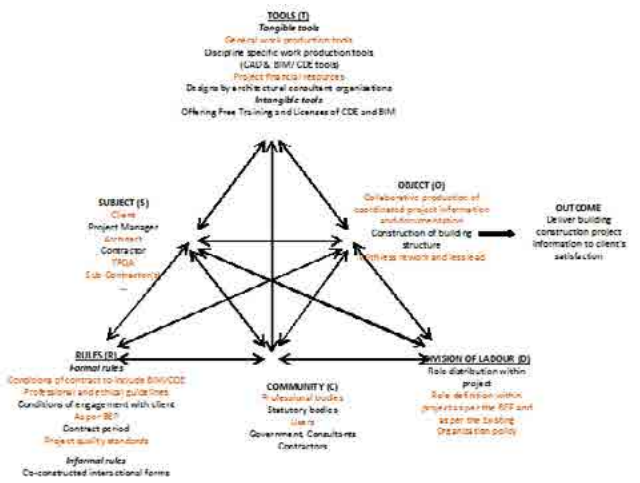

Fig. 2: Project Context Activity System

For example, approval of any design document is done in the hard copy in the existing system, however the same can be approved digitally with the use of CDE. The access of project data by different project stakeholders was another challenge as the conventional way of silo working won't allow the data sharing util it is finalized, whereas the BIM workflow may categorize the generated data/information as work in progress, final, shared, published etc. Compromises on the standard implementations were made to embrace the CDE and BIM implementation among the fewer stakeholders of the project. The objective of the CDE implementation was started with the document management and make sure the project documentations has fool proofed version control and thereby reducing the data/ information loss and reduce the searching time.

With the help of the project context activity system for the campus development project in figure 2, the project team had developed the CDE implementation workflow architecture for this project as shown in Fig. 3.

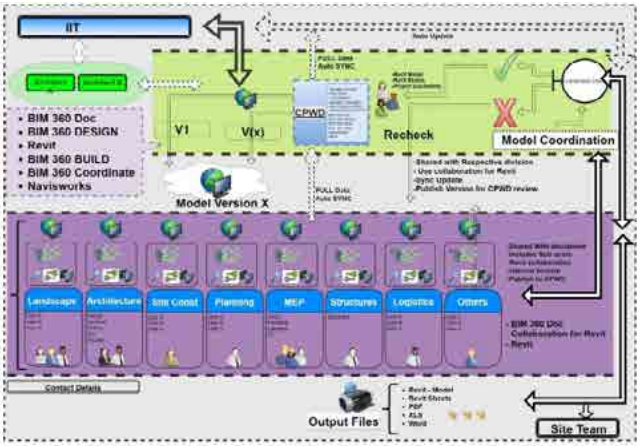

Fig. 3: CDE Implementation Workflow Architecture

The institute was administering the platform along with the executing agency (PMC) as co-administrator to manage the project information and documentation. Hence, continuous information flow among the stakeholders is ensured and delays are avoided. Data retrieval and data archiving are automated; hence version control and tracking are warranted. Further, the data collected can be utilized for the efficient deployment of the BMS with enhanced interoperability. The development of the project activity and information delivery protocol, the stakeholders were involved to work with the recently introduced CDE and BIM. The following section gives insights on the CDE implementation among the project stakeholders.

CDE IMPLEMENTATION EXPERIENCES

Continuous seamless information flow among the stakeholders is ensured using the CDE by the project stakeholders and delays on response to the RFI/ issues are minimized and has been completely eradicated towards the end of the project execution stage. Data retrieval and data archiving are automated; hence the design document version control and tracking are warranted.The CDE further extends the insight about the project RFI's, and Quality Issues which is used to analyze and perform

the timely interventions if needed.

The institute included BIM model development and CDE usage as part of its tender notice, this leads to the transformation on "rules" element in the activity systems shown in Figure 2. The contractor is asked to develop the clash free coordinated BIM model of LOD350/400 before the commencement of construction of each building in this project. The adoption of BIM and CDE reduced the physical clashes, more than 1300 RFI's were identified before the physical execution, and the same was resolved through the workflow designed in the CDE by means of changing the project information exchange and interface under the "tool" element of the activity theory depicted in Figure 2. Further, the developed model will be a lifecycle asset data repository for the institute, which aims to reduce the whole lifecycle cost of its assets through the deployment of appropriate BMS system by integrating the developed BIM Models with the BMS. The new roles are created among the stakeholders such as information/ interface manager who administer the project information through CDE as per the agreed access rights along with his organization employees. The implementation started in a phased manner with the involvement of 3 members initially from each organization and has been extended to 55 users belong to 6 different agencies. The reason attributed towards the increased uptake is because of the CDE and BIM capability. This includes but not limited to the access of the project data 24X7 through a secure login system among various stakeholders. The project-related metadata are recorded accordingly using the document management's powerful relational database. The full details of the project information such as who made the information contribution, when it was made (date/time stamp), the revision and suitability/status code for each of the project file exchange, etc. are recorded. In addition, it also allows the project participants to review the current and all previous revisions, it can be viewed and downloaded if necessary (historical record). Apart from the above-mentioned benefits, the below section elaborates the benefits realized by various stakeholders through the CDE and BIM implementation in this case study.

The CDE used in the current project has various levels of access permissions including, view, edit, upload, download, etc., for example, a viewer may not have design authoring tools or capability (such as BIM software installed on their system), but it allow them to review and comment on federated BIM model through the CDE. The metadata stored in this web-based platform may be used to provide an audit trail for files to determine the identity of the project actor and the activity performed during the execution. Further, the CDE allowed the project team to resolve the RFI's with details such as photographs, annotated markups, etc., to easily convey the content and get it resolved quickly. Automated version control plays a major role in the team in accessing the latest drawings and models. Further, the BIM model is utilized for clash detection before the project's physical execution. The quality control and documentation at the site are improved due to the 3D model access by the executing engineers at the site from the contracting and other stakeholder's side.

The implementation also left with challenges as the standard work procedures adopted in the organizations of the stakeholder's conflict with the proposed CDE workflow. Further, the awareness and willingness to adopt the CDE is minimal among the project stakeholders during the initial phase of the project. However, when the benefits are realized,adoption becomes easier. Though, more and more potential benefits exist using BIM with CDE, this project realized benefits in few key areas in a sustainable manner. More use cases, research, project procurement guidelines and standard operating procedures are the need of the hour to benefit most out of these types of initiatives. Some of the project CDE platform implementation snapshots are presented as the reference to the readers.

CONCLUSION

The implementation of project Common Data Environment (CDE) as a part of digital transformation on any project may induce alterations on its existing work activity systems. This has been explained and the same is demonstrated through a case study in this paper. From the implementation experiences, it is evident that the CDE is inevitable for all the AEC project which are demanding more and more collaboration among the stakeholders and among the project information interfaces. The activity theory has provided a valuable insight on the implementation processes, as it requires change/ transformation on various elements involved

Fig. Federated BIM Model in the CDE Platform

Fig. Interior View of the CDE for Informed and Quick Response

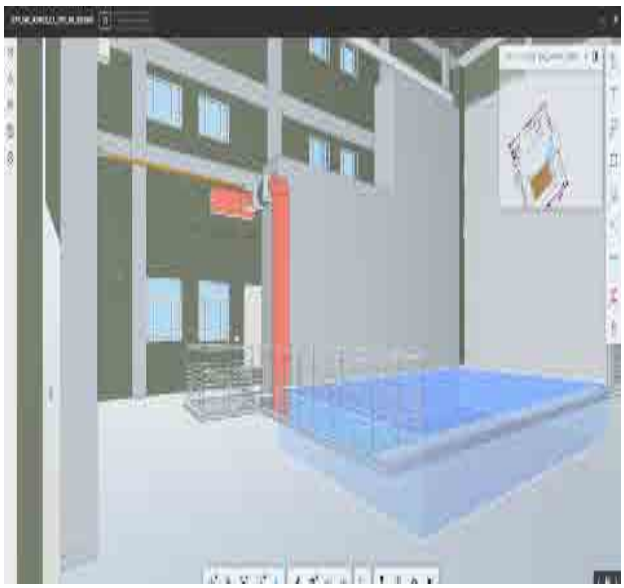

Fig. RFI Illustration in CDE

in anactivity system such as rules, roles, tools, community, objectives, subjects etc as explained in the activity theory. The system is dynamic in nature and its localized transformation may happen from the best practice standards around the world in a phased manner, as it needs adjustments from the existing work activity practices, including the rules, roles, objects, subjects etc. This is true especially for countries like India, as there are no guidelines, framework to follow on the implementation of these tools and technologies. The digital transformation is inevitable in AEC sector, and it is useful for managing the project data in an efficient way as illustrated in this paper and is agreement with the other research work reported in the literature. The implementation is non-static and project specific, it will evolve as the project organization evolves in the AEC projects. However, the analysis presented in this article only depicts the pattern of change due to the introduction of CDE as in the experiences of implementers in India, the same may be different in the context in which the implementation is mandated through a well-established/ matured rules and community of practice. The future study may be focused on the ROI of the CDE implementation and its value stream mapping through the life cycle of any project to appropriate the additional expenses and benefits among the various stakeholders of the AEC projects.

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ENABLING EPC CONTRACT WITH CDE & BIM

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Abstract

For large-scale infrastructure projects, engineering, procurement, and construction (EPC) contracts are becoming the most common type of contract. Project participants and stakeholders are increasingly cooperating in a collaboration network as a result of the increased complexity, variability, and uncertainty of large-scale projects. This enables them to share risks, resources, and information, as well as to investigate new experiences in order to jointly participate in the management of large-scale projects. As a result, this paper demonstrates how collaborative approaches, such as CDE usage using contractual obligations, and building information modeling (BIM) technology are used to drive large-scale infrastructure projects. A BIM-based collaboration platform for the management of the Ekatm Dham project is developed using a Hierarchy and web technologies. Its functions are implemented, including a model creation module, model management module, collaboration management module, workflow management module, Review Process, Communication & Correspondence standards to follow throughout the project life cycle, and system administration module. A working model of collaborative management using BIM technology for Ongoing Infra projects is presented in this paper. The prototype system is used in an ongoing "EPC 1" project to show how well collaboration works in a BIM environment and to force the contractor to follow the standards and use BIM technology to drive the project in accordance with the employer or employer representative's vision. The outcomes will emphasize the contractor's ongoing adaptability to technology, the benefits of using technology in the project, the importance of drafting the contract with the adoption of BIM technology in mind, and the key principles to constrain the contractor's implementation of BIM technology in the EPC contract.

INTRODUCTION

Building information modeling (BIM) and the common data environment (CDE) are now widely used in Construction industries. Not only is it a digital representation used to plan, design, control and maintain facilities, but it also affects how project participants traditionally define their roles and work together & the level of information extracted from the BIM models to help drive the project. The engineering, procurement and construction (EPC) method, according to several industry professionals, is not appropriate for BIM- enabled projects. In the following sense, parties to an EPC contract may have competing objectives. First, an owner wants to complete a project within a certain amount of time, within a certain budget, and in accordance with the desired specifications. On the other hand, a contractor wants to maximize profit from the project. Opportunism, in which one party does whatever it takes to achieve greater gains at the expense of the other, can result from the owner and EPC contractor's divergent positions. The nature of EPC projects, which typically involve high asset specificity and uncertainties, also makes it more likely that the contracting parties will engage in opportunistic behaviors. EPC contracts based on transaction law and a transaction cost economics approach typically impose contractual obligations that are more extensive. Contracts that are more thorough, allow parties to reduce uncertainty and, as a result, prevent potential opportunistic behaviors. On the other hand, the contracts might make it harder to work together in a BIM workplace and use CDE. Therefore, the contract must depict a descriptive vision and require EPC to adhere to the BIM Guidelines issued by the Employer or Employer Representative.

Through the lens of contract functions, it is argued in this paper that BIM & CDE Implementation in EPC projects can be implemented more effectively. By using this strategy, businesses can pay greater

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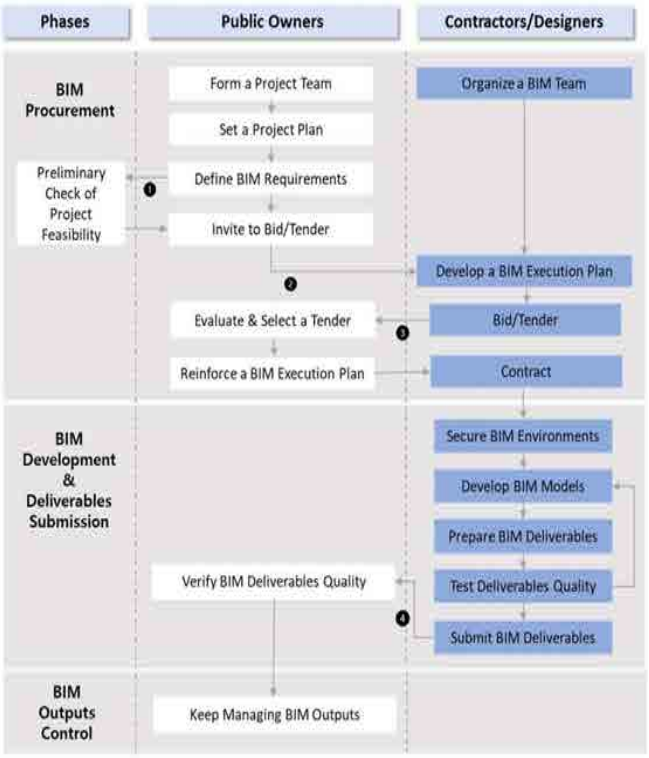
attention to each of the three purposes that formal contracts serve in order to increase exchange efficiency. Studies were conducted to know whether it could investigate co-operative behavior. In 1st study the effects of contractual control, coordination, and adaptation on various relationships (such as previous interactions, standard levels of cooperation, and voluntary cooperation) were investigated. In 2nd study investigated the connections between control, coordination, adaptation, and the voluntary and mandatory cooperation of contractual partners were investigated. The two studies demonstrated that contract functions can be used to investigate cooperative behaviors. In BIM, these functions can also boost project efficiency. Contract functions can be crucial to the effective governance of BIM-related projects because of the increased likelihood of opportunistic behaviors on the part of EPC contracting parties. Contractual control reduces opportunistic behaviors, and contractual coordination and contingency adaptability build trust between owners and contractors in each other's organizations. All these factors improve cooperative behaviors between contracting parties and boost performance. The performance of BIM-enabled projects is also improved when the three main contract functions are combined; reducing the negative effects of the individual contract functions. For instance, a contract environment that places an emphasis on coordination and contingency adaptability can build and strengthen trust, resulting in improved BIM performance. The current paper argues that the impact of contract functions on project performance may be influenced by the inter-organizational trust. A previous study by industry professionals on the effects of trust on relationships found that contracts have a positive effect on relational trust, but it did not investigate how contracts affect relational trust and contribute to project success. In addition, distrust, which is frequently perceived in contractual contexts, may have a beneficial effect on project performance while having a detrimental effect on exchange performance. Additionally, trust can be strengthened in a contractual relationship that prioritizes fairness, resulting in more productive collaboration. Another important factor that could affect the relationship between contract functions and BIM & CDE-enabled project performance and mediate trust between organizations is perceived fairness.

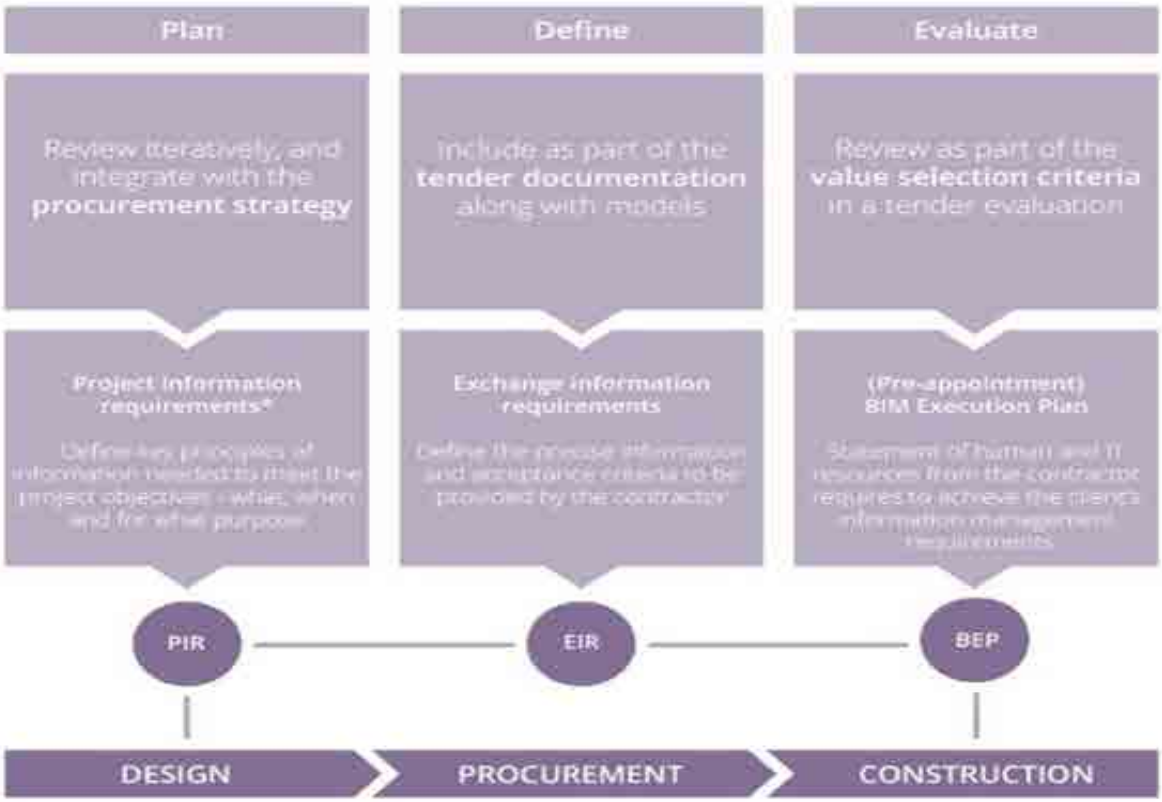
MEASURES TO BE TAKEN WHILE PREPARING CONTRACT PAGE

Prior research and BIM contract protocols served as sources for the measurement items for contract functions. Before responding to the questions, the respondents were given the opportunity to clarify any doubts. It's possible that some items for contract functions looked the same but had different meanings. For instance, the specific contract terms that specified damages against the party that failed to comply with the terms related to BIM deliverables (CON_2) and defined a right to audit for conformance in delivering BIM (CON_1) were used to measure contractual control. General controlling and monitoring of BIM deliverables terms (CON_3), such as the requirements of contracting parties to deliver BIM in accordance with the Employer & Employer Representative vision and the terms that specified solutions for non-conformance of BIM deliverables (CON_4), were also used to measure contractual control. Contrary to contractual control, contractual coordination provided dispute resolution provisions for parties to achieve collective action to resolve conflicts arising from BIM delivery for COR_4. Pre-tender implementation of BIM and CDE for successful post- tender implementation.

The below diagram shows the Working of BIM & CDE Technology in the project



In industry, there are set protocols established to execute the project using BIM Technology. If these standards are established in Pre-Tender Stage, then it will enforce the contractor to drive the project as per set & established protocols. ISO 19650 is a standard that drives the BIM tools & their application.



EMPLOYER VISION TO BE PROVIDED IN THE TENDER STAGE TO LET EPC CONTRACTOR BID ACCORDINGLY

Rather than focusing on the historical roles of various specialists like planners, architects, engineering designers, constructors, fabricators, material suppliers, financial analysts, and others, we can focus on the complete process of project management in conjunction with the implementation of BIM & CDE requirements by adopting the owners' perspective. Certainly, each field has made significant progress in the creation of novel strategies and instruments for the effective execution of construction projects. The Contractor, on the other hand, is able to respond more effectively to the owner's desires for their services, market their specialties, and increase productivity and quality of their work by comprehending the entire project management process. A few of the points which must be captured in the Tender Stage for the successful implementation of these technologies are:

1. Producing the Model Elements to the Level of Development (as defined in the Conditions) and at the project stage identified in the Model Delivery Table in Appendix 'n' of the Conditions.
2. Performing the additional modelling activities or uses identified in Appendix 1 of the Conditions.
3. Comply with all specified standards, processes, and procedures in respect of the development, use, transmission, exchange, storage, and archiving of Digital Data.
4. Appendix of the Conditions contains a Model Delivery Table which stipulates the required BIM modeling activities or uses and the respective responsible project participant at different stages of the project. Meanwhile, other Appendix can elaborate on Conditions that sets out the specific standards, methods, and procedures for BIM-related deliverables as well as the methods and procedures for the exchange and collaboration of digital data and models. These appendi-

ces serve as a useful tool to allocate responsibility and unify the standard of deliverables from all project participants.
5. Digital Data Exchange
6. Employer Information requirement in terms of BIM & CDE adoption.
7. BIM Management
8. Information Manager appointed by EPC Contractor, and
9. Setting the Protocols & Workflow for proper Implementation of BIM Techniques & CDE requirements.

CONCLUSION

Realize the Value of Project Data & Deliver Better Construction Outcomes with a Common Data Environment & BIM Technologies. Building Information Modeling is a powerful technology that is evolving in the Built Environment to ease each & every Stakeholder of the project. The direct and indirect effects of contract functions and BIM-enabled EPC project performance have been identified by this research. The findings of the study indicate that the connection between contract functions and EPC project performance is enhanced by the relational trust. A calculative trust may not significantly mediate the relationship between contract functions and EPC project performance, but its effects are more pronounced in terms of perceived fairness, as shown by this study. This suggests that when fairness is perceived, joint-contract functions may influence inter-organizational trust for BIM-enabled EPC project performance improvement. In addition, the research demonstrated that the calculative distrust influenced by joint-contract functions might not necessarily have a negative impact on project performance. To put it another way, a significant component of BIM-enabled projects is the calculative distrust that results from joint-contract functions and may not be detrimental to the performance of EPC projects. The examinations of the effects of joint-contract functions on the performance of BIM-enabled EPC projects and their mediating effects have provided relevant industries with valuable insights, primarily demonstrating that BIM can be successfully implemented within a traditional EPC contract setting. The current findings contribute to the development of knowledge regarding appropriate contract framing for stakeholders in BIM-enabled EPC projects, an area that has not been discovered or implemented effectively. However, in order for this complementary strategy to be utilized effectively in EPC projects, certain contract modifications should be made to influence trust, distrust, and perceived fairness between owners and EPC contractors. The likelihood of the EPC project succeeding is greatly enhanced by this strategy.

COMMON DATA ENVIRONMENT: A COLLABORATIVE WAY OF PROJECT MANAGEMENT

CHAITANYA KUMAR VARMA*

Abstract

A construction project if supported by information technology can lead to better timeline, proper management of budget and great reduction in errors during its execution. While time and cost overrun are the two major areas of concern in any civil infrastructure project, chances of errors always haunt the project team during the entire construction and operational phase. This leads to building up the tendency of shifting the blame to one another which further leads to non-cohesive working of those involved in the project. Common Data Environment provides the way to deal with this tendency by creating an error free environment with the help of sharing the construction data among various stakeholders from a single source. This also provides collaborative way of working which is required for successful completion of a Project. This paper deals with how environment created by common data strives to achieve collaborative way of working and many other aspects concerning Common Data Environment.

INTRODUCTION

A building before its construction, if conceived virtually may help greatly in visualizing problems in its planning, designing, construction, co-ordination and other related facets clearly. Information technology through building information modelling has strived to help building planners, architects, engineers to understand and prevent these problems before-hand and provide a plausible solution. But still the problem of effective communication persists. Unless the tremendous amount of data required during construction is conveyed to various stakeholders involved in the project at the right time, the project will not progress in the right direction. The communication of the desired information at the right time is therefore very important to send the alert to the stakeholders in sequence to get ready for their part of the action in the project. At the same time, it is also desirable that this information should be undistorted so that different people involved in the project understand same meaning of the communication rather than differently. Further, their interpretation of the communication should also be the same within the project team.

Fig. Digital Modelling & Execution Phase of a Civil Infrastructural Project

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This can be possible if entire data is stored at a central place and is accessed by authorized persons as and when required. This will lead to same interpretation as their will not be any ambiguity in its conveyance being emanating from a single source and is getting transmitted to different stakeholders who have the technology to access the information from anywhere and from any place. Since the data so generated is huge and depends upon the size of the project, storage of this huge data may be done on cloud. The arrangement so made will then form what is known in construction industry as Common Data Environment or CDE as its abbreviation or acronym.

Prior to the advent of CDE, the communication was not done simultaneously with all stakeholders but with only those concerned with either planning or designing or construction and that too by means of physical meeting. Subsequently, communication was done through email but with limited participants. Later, drop box etc., were also used to share huge files to facilitate distant communication. Thus, there was a slow, tedious and multiple communication prior to introduction of CDE. The situation is well depicted in the below image:

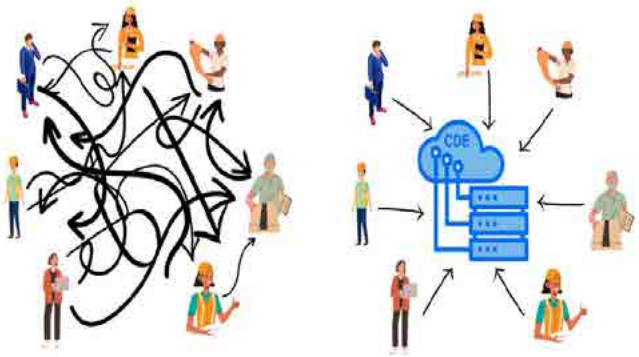

Fig. Work situation before and after CDE

COMMON DATA ENVIRONMENT

Common Data Environment or CDE's origin can be traced back to the development of BIM i.e., Building Information Modelling. Here the term information modelling is important to comprehend first. The information modelling is integration of the model of anything with the connected data and its related documents. Technically, an information model is a representation of concepts and the relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse. But for a general understanding, it is virtual representation of anything in 3 dimensions to understand various space relationships. Obviously, Building Information Modelling is Information Modelling of a building used for its construction including planning and designing. BIM is also known as VDC meaning Virtual Design and Construction.

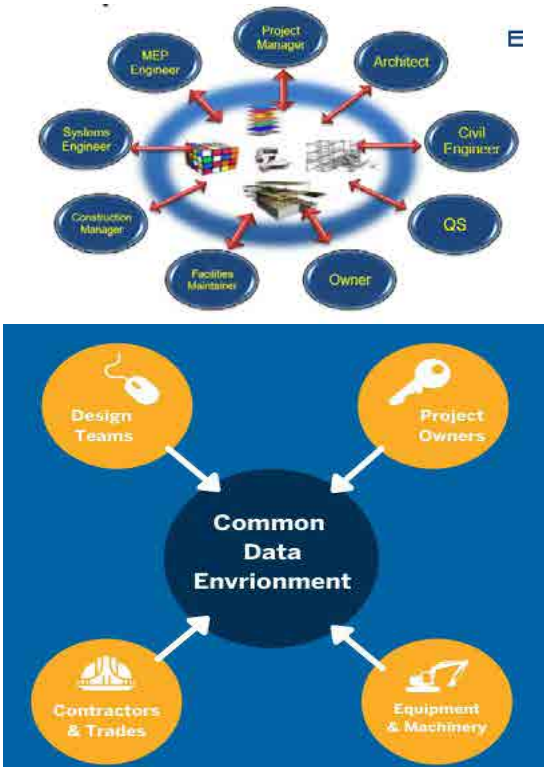

Fig. Linking of various project teams by CDE

Thus, from BIM to CDE it is a very interesting evolution in the building industry for the revolution in project delivery. While BIM is information model using digital means for the purpose of better coordination, CDE is combination of Information and communication model for effective collaboration of project team for better and timely delivery of the project eliminating all the wastes thus keeping financial resources under check.This paves the way for sustainable construction. CDE therefore, provides a communicative digital platform which is information based and in which information related to infrastructure project is readily available for use by different set of related people. Better information management can then improve the decisions to plan, design, inculcate features related to fire, structural and other needed safeties, energy

efficiency, net zero emissions etc., for delivering and operating these buildings/assets for the optimum safety, efficiency and utility. In a way, it provides secured and collaborative working.

More technically, the common data environment (CDE) is a central cloud-based digital store house where construction project and asset information are organized, accomplished, and warehoused. Information could include documents, graphical models, and non-graphical assets etc. Thus, CDE provides all the project data in an orderly way on one central platform available online to all the concerned people timely.

Creation of CDE however requires appointing a manager well versed in Information Management, establishing conventions, explaining workflows and setting up approval/sign-off procedures and processes. It also involves creating distinct settings for different teams, secured accesses and connect with and manage Building Information.

FOUR STATES OF CDE

The process of creating CDE involves four different and distinct states of operation as below:

1. Work in Progress (WIP) - Where information is being developed by the originator or task team.
2. Shared - For sharing of information which has been approved with the appointing party or with other appropriate and authorised parties or task teams.
3. Published - For information sharing which has been authorized for use, either in the construction of a new project or in the operation of an asset.
4. Archived - To hold a complete record of all that have been shared and published during the information management process.

HISTORICAL PERSPECTIVE OF CDE

The story of development of CDE is equally involved and interesting and signifies a brief mention here. It is noteworthy to indicate that CDE in its present form can be traced back to the development of BIM which is acronym of Building information modelling. BIM in reality is a detailed virtual model of a building for integrating multi-disciplinary data conceived for better design and construction ensuring real time coordination between different services, quality and safety aspects thus preventing any avoidable delay and mistake in its execution.

The concept of BIM came in 1970 to eliminate the problem of co-ordination between various organs of the building management but became an agreed term only in early 2000s. The software tools developed for modelling the buildings in the late 1970s and early 1980s were quite primitive and expensive. These include RUCAPS, Sonata, Reflex and Gable 4D Series etc. However, these applications and the hardware were quite expensive. This prevented their widespread adoption.

The term Building Model was used first in mid 1980s and the term 'Building Information Model' first appeared in 1992. In 2002, Autodesk released a white paper entitled "Building Information Modelling and other software vendors also started to assert their involvement in the field. This started the popularisation and standardisation of the term BIM as a common name for the digital representation of the building process. ArchiCad was launched in 1987 is regarded as first implementation of BIM.

The common data environment (CDE), was subsequently originated in BS1192-2007 by Mervyn Richards OBE in Britain and was considered to be the single source of information for gathering, managing and disseminating documentation including graphical model and non-graphical data for the whole project team. This was irrespective of the fact that all project information was created whether in a BIM environment or in a conventional data format. Thus began the journey of CDE.

STANDARDS DEVELOPMENT OF CDE

Standards are formulated for ensuring quality, safety and best practices and have progressed to develop at varying speed in various countries. With, the advent and successive use of BIM (Building Information Modelling) in the construction project delivery, efforts were initiated to standardise the necessary framework to safeguard the above virtues. Accordingly, the Common Data Environment got its first standard way back in 2007 in the form of BS1192:2007 which is a British Standard. Later, PAS 1192-2:2013 was developed to achieve level 2 BIM in 2013. PAS stands for Publicly Available

Specifications. These are rapidly developed standards/Specifications or Codes of Practice/ guidelines which subsequently got converted into National Standard.

Finally, it has got international standard ISO 19650 by 2019 which is structured on the premise of controlled sharing of data after necessary and required checks. By this international standard, total information management system relating to the built asset over its entire life cycle has been standardised. This standard has provided clear definitions of the information required by various stakeholders along with methods, processes etc. for effective and efficient transfer of information among team members of the project. CDE has thereafter no longer remained merely a technology solution but became a standard process.

BENEFITS OF CDE

- The most remarkable benefit of the CDE is in creating a single source of true information in the construction industry which is always marred by the multiple distortions. No one in the team which implements project through CDE can claim to receive a different information thereby eliminating the problem of miscommunication.
- Often within project team, there is a tussle over lack of teamwork and cohesion. One of the main advantages of CDE is enhanced collaboration. In fact, team members have no option but to work in most cooperative way with other members of the team. In a way, human behaviour is at its best out of fear of being caught by digital intervention.
- Efficacy of human system also improves the efficiency with which construction progresses. Quality is another aspect which also takes a front seat when this system is adopted because every entity has to give their best.
- The risk of failure and risk of loss of time are also greatly reduced. This serves the very cause for which this system has been devised.
- Transparency and Productivity both are improved as an outcome of adoption of CDE.

ANTITHESIS OF CDE /CHALLENGES

However, there are ample challenges also in creating a digitally built communicative environment. These are:

- Complexity of IT System - The IT system required to be procured for fulfilling the desired objectives needs careful balancing of the needs of the project and the finance involved in the procurement. The complexity of the system increases with the addition of more and more features which should be taken into account while making a final decision.
- Cost & Resources in Procuring the System - Cost of such systems is normally quite high as these are to be customised as per the customer needs. There are other cost factors like the costs of on-site file servers and additional network storage which may put strain on IT Budgets.
- Time Cost - Time costs of searching across multiple systems and silos every day to answer simple project queries may additionally create a burden on the time of different stakeholders.
- Security of Data – Data security is of prime concern here as the IT system having multi functionality will house multiple data. This Big data will require encryption to a great extant. Thus, security features are required to be in-built into the system and need to be updated from time to time.
- Developing a System Compatible to the Existing Processes of the Organisation - Many a times particularly in an older organisation, the system to be developed is as per the needs of the user organisation. This is quite an involved task and requires toll on time and human resources of both i.e., user as well as developer organisation to understand and dovetail the system to the user's requirement. Multiple user testing and interactive sessions involved in the process increase the time requirement. There is also a risk that by the time system is developed, a better system may come in the market thus obviating the need of earlier system.

Thus, a comprehensive evaluation is to be made prior to adopting CDE for the project Management of the organisation.

FUTURE CONSTRUCTION TECHNOLOGIES

It is also imperative here to have a glance into the future of construction domain. The construction industry is one of the least digitised sectors as per 2019 Mc Kinsey's report. Lots of innovations and smart technologies are therefore waiting to come in this arena. 3D printing is one such technology which will soon engulf construction projects and has the potential to create houses in a matter of days. Further, engineers and architects globally are also using digital twins which is a step further to CDE and is essentially a virtual model designed to truthfully reflect a physical object in order to improve decision making and sustainability in building construction, operation and maintenance.

Construction technologies are now developing at fast pace. Digital collaborative contracts are also going to take over the physical contracts very soon. These are e-contracts which can eliminate many flaws in existing contracts and will alert the defaulter at the time of default itself. Many digital features will exist in this type of contract. ConTech i.e. the technology used to innovate the way structures are planned, designed, and built, as well as the manufacture and installation of their components is another next big thing poised to happen in construction industry for improving every aspect of asset lifecycle.

Glimpse of these futuristic version of construction technologies is not fantasy at all. Nevertheless, we have to concentrate on CDE at present to eliminate the holdup of coordination and collaboration in infrastructure projects for their smooth and safe completion.

CONCLUSION

It is thus quite obvious that CDE encourages collaborative working and that too with the ease of operating from anywhere and any place. Collaborative working accomplishes all tasks for the mutual benefit of all team members in the desired sequence. Wasteful exercises are reduced with creation of better work environment as a result of collaborative working. Thus, besides saving time and money, it also improves efficiency through the entire life cycle of the infrastructure project. Since there is a permanent record of the building, any problem concerning the project can be handled timely, economically and efficiently. It also creates a strong information management system for future working practices. Risk of building failure therefore reduces due to reliability of data. Coordination between different agencies also improves because of proper communication and information management system. Greater reliability of data is ensured during design stage while during construction stage the risk of failure is reduced substantially. Undoubtedly, more efficient processes are selected for the construction due to availability of huge data and data analytics as a tool to process the big data.

When the building comes into operation, the construction stage information is transferred accurately as well as reliably in order to take timely and appropriate decision by the operational team when any defect is observed. Estate planning, procurement and maintenance is also improved substantially by the intervention of this system.

Thus, transformational changes as mentioned above are brought in the project delivery and its subsequent operation and maintenance resulting in more sustainability in creation of built assets.

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CLOUD BASED INFRASTRUCTURE MONITORING MECHANISM USING WEB BASED PROJECT MONITORING PORTAL

COL. NAVEEN MEKA*

Abstract

Military Engineer Services (MES) is one of the largest and oldest construction agency rendering active works services to Armed Forces. Till October 2021, there was no unified digital platform to monitor infrastructure projects executed by the MES. Therefore, it had largely resorted to manual process of reports & returns in monitoring projects. This impinged latency in reports, non-uniformity of formats, snailed efficiency etc. E- governance in MES has been a long drawn necessity to ensure real time monitoring of works, fostering efficiency and to unlock latent productivity. Therefore, Web Based Project Monitoring Portal (WBPMP) was the first cloud based project monitoring solution to have been implemented in the MES ecosystem. The web application is an internet facing application to monitor capital and special repair works executed by Garrison Engineers pan India. MES has its large presence at various stations across the nation including at remote fringes of border areas. Thus, implementation of e-governance solutions have been fruitful & effective to achieve the above merits. Voracious implementation of WBPMP has thus enabled digital transformation, making quick availability of information to decision makers using a common data shared environment at the click of the button.

INTRODUCTION

Military Engineer Services (MES) is one of the largest construction agency rendering work services to three services viz Army, Air Force and Navy pan India. MES also extensively caters to infrastructural development and maintenance of assets for other organizations such as Defence Research and Development Organization (DRDO), Directorate General of Quality Assurance (DGQA), Coast Guard, Kendriya Vidyalaya Sangathan, Ordinance Factories etc. E-governance in MES was an essentiality in fostering efficiency and to enable expeditious work services. Incorporation of good governance triggered a transformative leap forward through pervasive digitization to bring greater flexibility, transparency, scalability, to foster responsiveness etc (1).

Footprints of MES has a wide spread presence pan India. Remoteness of stations particularly at Northern, Eastern borders and sparse Islands made a daunting challenge in implementing project monitoring solution. In order to obviate this criticality, WBPMP was developed through Bhaskaracharya National Institute for Space Application and Geo-informatics (BISAG-N) based on functional requirements rendered by the MES. The initiative have been steered aggressively in mere span of one year.

WBPMP is a unified project monitoring solution to have been implemented for the first time in MES at a large scale. This cloud based mechanism is an internet based application binding all stakeholders of MES as well as its users accessing common repository of data. WBPMP has thus fostered efficiency, enabled speedy decision making capability and achieved an effective paperless monitoring mechanism (2).

SCOPE OF APPLICATION

WBPMP is a unified portal to capture life cycle information of capital and special repair projects from their inception till their completion. The portal captures data from Administrative Approval onwards till final stage of completion. Total of 94 static fields pertaining to any given project is captured at the grass root level entity. A Garrison Engineer (GE) is the first entity in the MES who is responsible to execute projects, thus, the application captures information from this first entity. The overall

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proforma breaks down entries into three stages viz basic project details, post administrative details and execution related information.

The details of project by Garrison Engineer is further validated by one up level entity by his Commander Works Engineer (CWE). Thereafter, the information is viewed by all concerned stakeholders from GE level upto the highest Headquarters thereon. In addition, Armed Forces users to whom MES renders active works services also access this common data information in form of predefined format of reports. This ensures intricate monitoring of projects by all responsible stakeholders. The system generates 13 pre-format reports and returns such as Monthly Progress Report (MPR), Quarterly Progress Report (QPR), project wise expenditure report, hinderances encountered while execution of work, Contractual details, physical and financial completion status, observations of Technical Examiners (TE) visiting work sites, maintaining record of visiting officers to sites such as the Project Management Group, MES stakeholders & formation commanders, comprehensive repository of projects, targets pertaining to tendering of contracts and planned physical completions etc. as overall repository of works is created in the form of common database (3). The application is hosted on NIC cloud, thereby connecting all stakeholders to access information using internet as a medium.

OPERATIONAL WORKFLOW

Garrison Engineer on receipt of Administrative Approval will first create a work on the portal with auto-generated unique ID by entering basic administrative details related to a project. Details such as name & value of the project, approving authority, date of accordance, original date of completion etc. Upon approval by his CWE, two additional proformas are opened for entries viz post-administrative and execution details. Post-administrative details pertains to information prior to conclusion of contract and execution details are those during the execution of work, i.e. with effect date of handing over of work site to the contractor. Further, the Garrison Engineer will update respective works on the monthly basis. The process will be continued till the completion of the project. The process of online validation by CWE is mandatory for every entry/updation made by the GE. During the course of process, the pre-format reports will be generated automatically under the report tabs. All reports will not only be accessed within the technical chain of command but also by the staff channel (mapped with specific or multiple Chief Engineer Zones).

Slippages in monthly updations will automatically trigger email reminders to his CWE within 24 hours, Chief Engineer in 48 hours and 72 hours to higher Headquarters. The information validated by CWE is then available to all stakeholders as common data in from of uniform reports. In addition, messaging and broadcasting facility within the application enables seamless and encrypted communication among the stakeholders (4). The work flow of the application is at Fig.1.

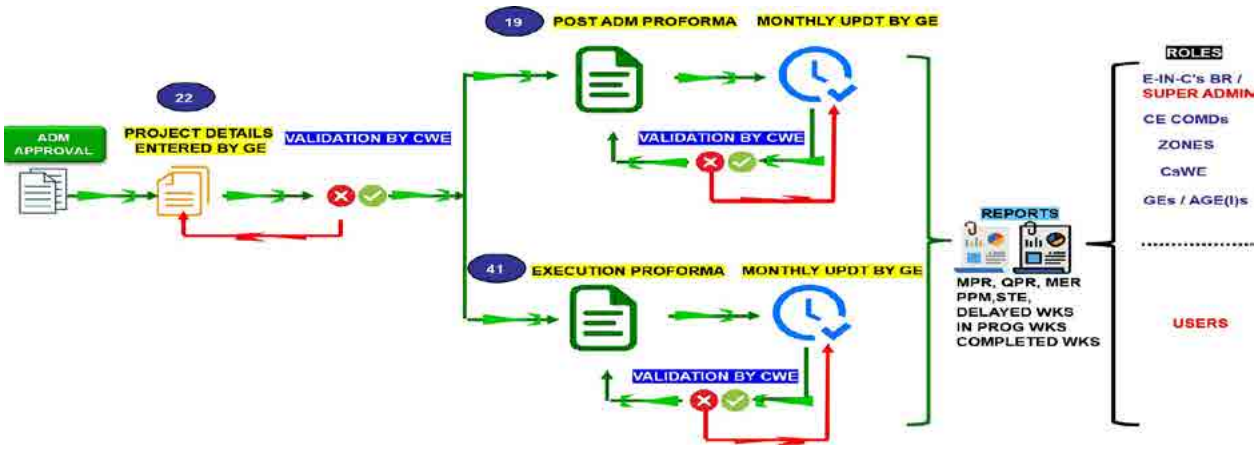

Fig. 1: Operational Work Flow

- **Project Proforma**

Initial data entry is required for a new work or project with all mandatory fields as in project proforma page. The submitted data is stored into database along with a fifteen digit unique ID which is automatically generated against each new entry of work for future reference. The details captured in proforma is at Fig.2.

Fig. 2: Project Proforma

- **Post-Administrative Fields**

Post administrative details of the project encompass details prior to conclusion of contracts. Details such as planned/ revised physical date of completion, contract details, soil investigation status, targets set by competent engineer authority, hindrances faced etc are entered by the executing engineer. The details captured in proforma is as seen in Fig.3.

Fig. 3: Post-Administrative Proforma

- **Execution Fields**

  Execution details of the project encompass details after the conclusion of contract and post handing over of site to the contractor. Details such as completion target, physical & financial progress, hindrances during execution of work etc are entered by the GE. The details captured is as seen at Fig. 4.

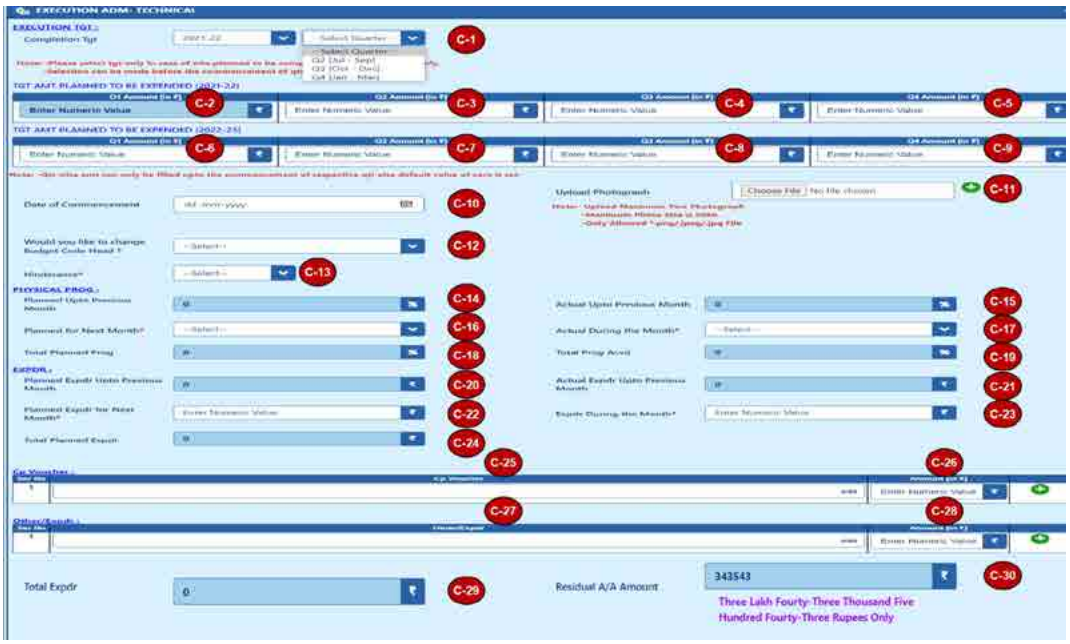

Fig. 4: Execution Fields

STACK, FEATURES AND DEPLOYMENT ARCHITECTURE

In compliance with GIGW guidelines (5), the application has been developed using free and open Source Software (FOSS). Development of application has been carried out using Java, PostgreSQL using Spring MVC framework. The beta version of the application was developed in mere span of 100 days. The deployment of the application has been made on the NIC cloud consisting of Virtual Machines (VMs) for web application server and database server. Features provisioned in the application are as follows:-

- Geo-fencing enabled.
- Extensive use of info-graphics for easy assimilation.
- Two factor authentication has been used with the OTPs being sent to gov.in/nic.in e-mail IDs (SMTP services).
- User friendly prompts and pre-format reports.
- Transparent Data Encryption (TDE) for server-level encryption and pg-crypto at application-level encryption.
- Drill down in seeking data upto the lowest level is possible.
- Assisted with multiple filter options.
- Date and time stamped reports can be generated.
- Time lapsed auto-mailer alerts.

The deployment architecture in the Militarized and De- militarized zones is seen the Fig. 5.

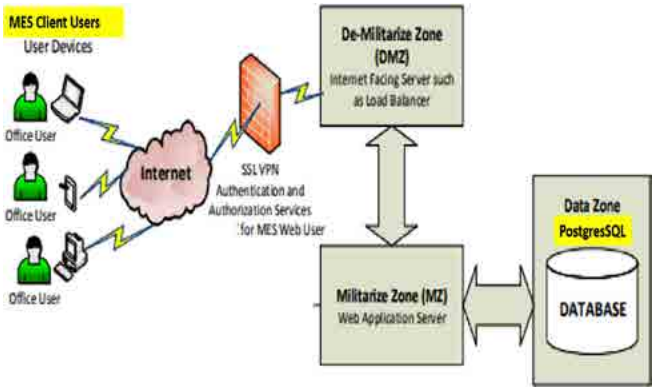

Fig. 5: Deployment Architecture

SECURING OF CLOUD COMPUTING SYSTEM

Managing the risks though a public cloud deployment is ideal for most uses that are not sensitive, mission critical, migrating sensitive or proprietary data into cloud environment which is not certified nor designed to handle data associated risks. Therefore, we selected cloud deployment model and that makes sure that sufficient security controls are active in place. The sections are followed by reasonable risk assessment thereof (6):-

- **Data and Encryption -** If the data is stored unencrypted in the cloud, data privacy is at acute risk. There is a risk for unauthorized access either by a malicious intent from the cloud service provider side or an intruder trying to gain access to the cloud infrastructure externally.
- **Data Retention -** When the data is migrated or removed by the cloud provider or customer, there may be data residues which might expose sensitive information to unauthorized access.
- **Compliance Requirements -** Varying regulations with respect to data privacy in compliance with OWASP Top 10 and CWE SANS - 25 have been met. Public cloud providers do not provide information about the location of the data. Thus it was imperative to consider regulatory requirements about where the data can be stored.
- **Multi Tenancy Risks -** The shared nature of public cloud environment increases security risks, such as unauthorized viewing using the same hardware platform. The shared environment also presents resource competition problems whenever one of the customers uses most of the resources either due to need or due to being exposed to targeted attacks, such as DDoS.
- **Control and Visibility -** There has been restricted control and visibility over the cloud resources since the cloud provider is responsible for administering the infrastructure. This induces additional security concerns which originate from the lack of transparency.
- **Security Responsibility -** In a cloud, the service provider and the user shares the responsibility of securing the environment. The amount of responsibility is shouldered by each party which can change depending on the cloud model.

OWASP TOP-10 AND CWE SANS-25 COMPLIANCE

WBPMP is in compliance with Open Web Application Security Project (OWASP) top ten and Common Weakness Enumeration (CWE/ SANS) Top 25 vulnerabilities as shown in Fig. 6 and 7. Application security deals with securing the programmatic logic of the underlying application. Varying from application security, software security it focuses on the stages of the software development life cycle (SDLC) and the underlying code of an application (7). It is easier to secure an application that has fewer defects and vulnerabilities as follows:-

Fig. 6: OWASP Top 10

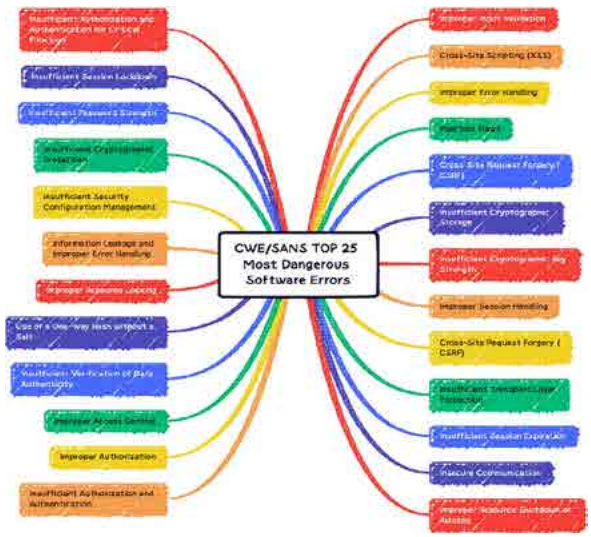

Fig. 7: CWE SANS Top 25

- **Injection** - Most of data could be subjected to injection and vulnerabilities which are often found in SQL, LDAP, XPath, or NoSQL queries, OS commands, XML parsers, SMTP headers, expression languages and ORM queries.
- **Broken Authentication** - Due to leak of information, the attacker can access to user credentials or administration panel.
- **Sensitive Data Exposure** - The attackers steals the keys and execute man-in-the-middle attacks or steal text data off the server while in transit or from the user client, example browser where a manual attack is generally required. The previously retrieved password databases could also be brute forced using Graphics Processing Units (GPUs).
- **XML External Entities (XXE)** - In XML format documents, the data is represented using XML entities which are built into language. These entities can be custom- defined or located outside and loaded from external sources such as the local files. Such XML inputs with external references are known as XML external entities.
- **Broken Access Control** - The access control is a security mechanism in putting restrictions on the accessibility to the resources.
- **Security Misconfiguration** - These are security controls that are inaccurately configured or left insecure thus system and data both are at risk. These are poorly documented configuration changes, default settings across any component at the end points leading to a misconfiguration.
- **Cross-Site Scripting (XSS)** - Also known as XSS is a web security vulnerability which allows an attacker to compromise interactions that users have with vulnerable application. It allows an attacker to circumvent the origin policy which is designed to segregate web applications.
- **Insecure Deserialization** - When a user-controllable data is deserialized by an application. This potentially enables an attacker to manipulate serialized objects in order to pass harmful data into the application code. It is also possible to replace the serialized object with object having entirely different class.
- **Using Components with Known Vulnerabilities** - such as libraries, frameworks, software modules that run with the same privileges as the application. In case the vulnerable component is exploited, such an attack can facilitate severe data loss or server takeover.
- **Insufficient Logging and Monitoring** - The logs give visibility to activities. Logs and audit trails generated enables to trouble shoot, track events, maintain regulatory requirements and detect incidents. Insufficient logging and monitoring causes missing security critical information logs.

ENCRYPTION MECHANISM

MES being a military organization and nature of works undertaken requires the data to be kept secure against potential cyber attacks or phishing activities. Therefore, in order to achieve this, encryption of data was implemented two pronged. Encryption of data was at server level using Transparent Data Encryption (TDE) and at application level using pg-crypto. The enabled selected fields are encrypted to 256bit AES thus making the application more resilient. In addition, encryption of data during transit using SSL-TLS and while at rest has been achieved holistically. Transparent Data Encryption (TDE) is an encryption method that protects the core data in the database (8).

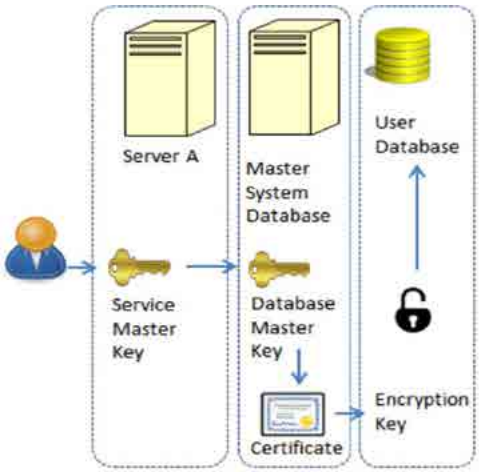

Fig. 8: TDE Architecture

The method protects data stored in the database by encrypting underlying files and not data itself. This primarily prevents the data from being hacked or being copied to another server. Therefore, in order to open the files, we have to have the original master key or the encryption certificate. Encryption of the database is done at the page level. In the context of the actual database, page refers to the unit of data storage in the server and not a web page. Therefore, Transparent Data Encryption (TDE) operates at the structural level of the database.

TDE is considered as at rest encryption method. It protects data as it rests or when stored in the database. Transparent means that the encryption method is transparent to authorized users of the database. Therefore, they do not need to create any special macros or update complex configurations to access the data (9). The TDE architecture is as seen the Fig.8.

IMPLEMENTATION AND CHANGE MANAGEMENT

The development of application was completed and rolled out for use with effect from Oct 2021. It was extremely challenging to implement the application at pan India level. Especially the change management activity which had entailed six months of training imparted to MES stakeholders during the pandemic. As the business logic work flows for the application was developed from the scratch and not time tested Custom of the Shelf (COTS) (10) (11) type, the application required significant gestation period for stabilization especially with respect to continued realization of bugs. Now over a period of one year, the application has reasonably attained stability with only few glitches now being encountered. In addition, acquainting application to users in the environment with respect to functionality was time taking and needed close supervision on daily basis. The implementation phase was broken down into five steps as illustrated in Fig. 9.

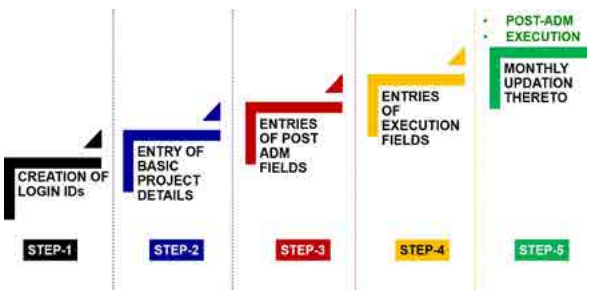

Fig. 9: Five Stepped Implementation

OTHER E-GOVERNANCE INITIATIVES

MES has also spear headed implementation of several e- initiatives in other functional aspects such as budget management, digitized measurement of work, enlistment of contractors, approvals of products etc. The following applications will be integrated to each other to achieve a comprehensive works management solution in due course. Brief on the following applications are as mentioned below:-

- **Electronic Measurement Book (EMB)-** Electronic Measurement Book is a web based application enabling to record physical measurements at work sites. All stakeholders responsible such as GEs, AGEs and contractors access the application. The system captures process of billing - Running Account Receipts (RARs), Final bills, Deviation Orders etc.
- **Budget Management Portal (BMP)-** The application captures the budgeting process related to demand and allotment of funds. It automates the process of forwarding estimates under the stages of Budget Estimation (BE), Forecast Estimate (FE), Revised Estimates (RE), Prelim Revised Estimates (PRE) and Modified Appropriation (MA) etc. Code head wise demand of funds originating from GE office onwards to highest Headquarters is addressed through the application including allocation of funds, re-appropriation, surrender etc by the competent authorities. The system generates time filtered expenditure reports to the budget stakeholders.
- **Work Estimation Application (WEA)-** The application has been developed to assist executives in preparation of expeditious work estimates. The estimates are based on pre-fed database of Standard Schedule of Rates (SSR), Estimated Data (ED) rates, Plinth Area (PA) rates and prevailing local marketrates.

- **Contractor and Consultant Enlistment Portal (CCEP)-** The application will facilitate online enlistment / renewals of contractors and consultants pan India. The automated process entails activities of enlistment of contractors & consultants, renewals, class up-gradations, initiation of work load returns etc. The application will foster transparency to a great extent.
- **Electronic Cashbook (ECB)-**The application enables voucher based accounting system to capture financial transactions at Garrison Engineer offices. The application generates vouchers, receipts, monthly account summarization and expenditure reports etc.
- **Product Approval Portal (PAP)-** The application facilitates single window mechanism for all the activities entailed towards online registration/ renewals of products being incorporated in MES. It indicates real time status of approval/rejections of applications by the competent authorities. Capturing status of evaluation proceedings, maintaining repository of products with specifications pan India. Role based access has been given to the concerned stakeholders through secured login.
- **AMWP Scrutiny & Status Application (Local LAN) -** In order to enable expeditious processing of Annual Major Works being received at Headquarters for scrutiny. The process has been automated for tracking movement of case files. The application shows status of those under scrutiny, cleared and approvals accorded.

CONCLUSION

WBPMP is the first project monitoring solution to be implemented in the MES. Approximately 25000 works are currently being monitored over the portal based on several evaluating parameters. WBMP generates standardized reports in specified formats for use by different stakeholders as per their requirements. The current process of manual reports can be obviated on account of common data repository available to all stakeholders. The web application will certainly prove to be beneficial and be effective in times ahead in evaluating overall health of MES infrastructural projects. In addition to WBPMP, implementation of several other e-initiatives will go a long way in instilling enhanced work efficiency by resorting to apropos cloud based solutions.

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COMMON DATA ENVIRONMENT AND BUILDING INFORMATION MODELLING

DR. K. M. SONI*

Abstract

Common data environment is an agreed source of information for any given project for collecting, managing and disseminating information from the data available at a single place. Since a complex project has large data collected and shared by various stakeholders to be utilized by various stakeholders like consultants, designers, engineers, contractors and vendors located globally, CDE has become essential. CDE uses best practices to improve project workflows and tasks for efficient project management.

CDE supports Building Information Modelling (BIM) which can model the designs and services virtually enabling owners and stakeholders to visualize the project before it is constructed at site.

CDE and BIM are essential for successful design and execution of complex projects.

INTRODUCTION

A project has various components depending upon its requirements like Civil, Electrical & Mechanical services, Horticulture, Fire services, Security services, Audio-visual etc. Each component has large data which are analyzed by the designs of each component separately, however the project is successful when all data get synchronized. Common data environment (CDE) is a digital information platform that centralizes project data storage and access, typically related to a construction project. CDE provides a platform for the project data to be stored including changes to be recorded, distributed, and resolved resulting into a more efficient delivery team. CDE is supported by Building Information Modelling (BIM).

BIM is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of services and places. BIM is used by individuals, builders, contractors, architects, engineers and government agencies who plan, design, construct, operate and maintain buildings. BIM is used in buildings as well as in other infrastructure. BIM has many levels nowadays.

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The stakeholders like architects, engineers, designers and construction professionals rely on BIM working within a CDE (Fig. 1) to bring greater control and efficiency to the projects. BIM data are stored in a CDE and also may include documents like project contracts, estimates, reports, material specifications, and other information relevant to a project's design and construction processes. Thus, CDE is an inclusive repository of data generated by a project team through the design, construction, and operation phases. CDE can be accessed by the teams and individuals of multi-disciplinary project stakeholders anytime and anywhere using a computer, mobile phone, tablet, or machines in the field.

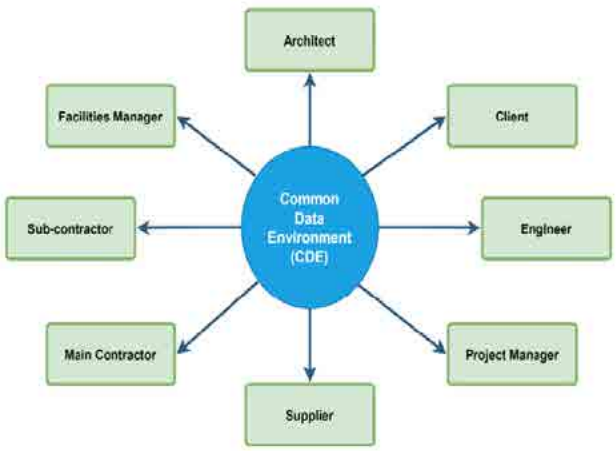

Fig. 1: Stakeholders of CDE

DEFINITION

ISO 19650 defines a common data environment as an "agreed source of information for any given project or asset, for collecting, managing and disseminating each information container through a managed process". Requirements for a CDE include the following;

- Use of unique identifier for every information container and standard naming convention
- Assigning a suitability status to all data
- Controlling data revisions to ensure past revisions are not being reused
- Implementing audit trail

ISO 19650 has also provided the definition of BIM as "use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions". The US National Building Information Model Standard Project Committee describes BIM as "Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition". BIS has also constituted a group to formulate guidelines for BIM which will define it paving the path for formulation of code of practice.

Therefore, CDE is a digital information platform that centralizes project data storage and access, typically related to a construction project and BIM workflows and may also include documents like project contracts, estimates, reports, material specifications, and other information relevant to a project's design and construction processes. Thus, CDE is an inclusive repository of data generated by a project team through the design, construction, and operation phases. Multi-disciplinary project stakeholders can access the CDE anytime and anywhere using a computer, mobile phone, tablet, or machines in the field.The contents of the CDE are not limited to assets created in a 'BIM environment' and include various documentation, graphical model and non-graphical assets.

ELEMENTS OF CDE

CDE uses best practices to improve project's typical workflows and tasks for its efficient project management. The following elements may be part of CDE;

- Sharing and organizing project data with central file management system
- Recording submittals, request for information and deviations/variations (change order) and tracking the processes
- Real time design collaboration with centralized BIM
- View and extract data from BIM without accessing BIM software
- Integration of field and equipment apps with office and filed teams

A central file management system within CDE allows all stakeholders to access it (Fig. 2) and get the status as the project documents are centrally stored and shared amongst the project team. These files may be made accessible to the required persons and officials such as designers, engineers, contractors, owners, and operators. Files can be shared within a group of certain stakeholders even though they are stored in CDE.

Another advantage in CDE is submittal process. For an approval of the case, certain documents

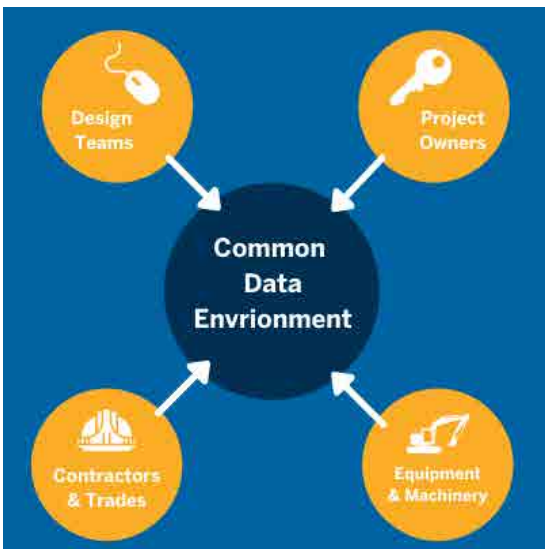

Fig. 2: Stakeholders in a CDE

may require processing through many officials/ stakeholders and once approved, may be required to be sent to a few identified authorities. As such, tracking can also be done. Through CDE, submittal process, request for information and deviations/ variations/change orders can also be streamlined for avoiding cost overruns and time overruns. Even, the comments and observations can be recorded during the communications between various stakeholders.

In a project, various services are required hence there may be designers and engineers for various services using different BIM models. Centralized BIM can provide access to all the stakeholders for the designs and revisions. Through CDE, tracking of the designs can also be made. All clashes of services can be detected in advance through BIM resulting into the scarce resources and time resulting into a quality work.

BIM is mainly used by the designers and architects however certain data and designs are required and to be accessed by other stakeholders like contractors and owner without accessing to BIM App for their requirements in the project like rendering, report generations etc. hence CDE helps them. CDE also helps in integrating field updates with the model.

AVAILABILITY OF CDE AND BIMS

Various cloud based CDE platforms are available in the market for the construction industry. Also there are many BIM models and can be used as per the requirement. Benefits of using CDE in construction are as follows;

- Data can be accessed at any time and from any place by the person to whom access is given
- Prevents loss and manipulation of data
- Collaborates team approach
- Makes data available for further analysis
- Improves project quality and efficiency
- Creates confidence and helps to build trust among the project participants to capture a complete record of the project with a unique data ownership model that eliminates barriers to collaboration, increasing adoption and data sharing across the entire project team.

CREATION OF CDE

CDE is created generally by the following steps;

- Appoint an information manager
- Establish conventions and workshops
- Define workflows and set up approval/sign-off processes
- Create distinct environments for different teams
- Keep accesses secure
- Connect with and manage BIM

It is not essential that CDE and BIM are going to provide successful project management as even BIM depends upon availability of qualified staff, effective leadership, and availability of information and technology with the CDE/BIM consultant. Thus, CDE is a platform and BIM a tool for successful completion of a project.

APPLICATIONS OF CDE AND BIM

CDEs can be used in large and complex civil and

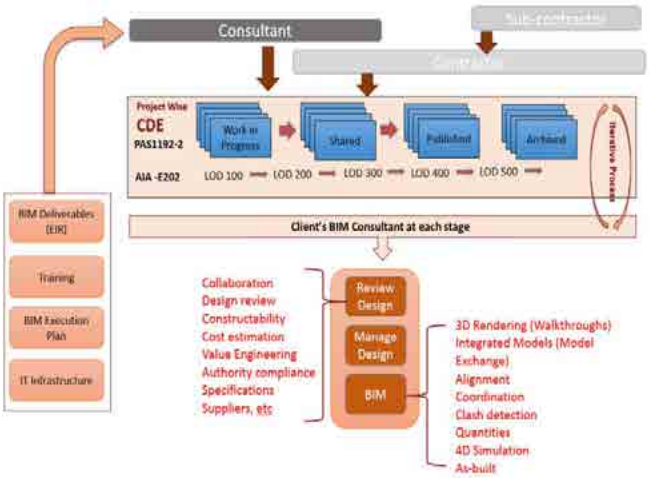

Fig. 3: Advantages and steps of CDE

infrastructure projects including buildings requiring exchange of large volumes of data, ranging from designers to contractors to owners and easy access to real-time project data.

BIM services may include architectural services, structural services, MEP services, co-ordination services, energy services and facility management services.

3D BIM represents three geographical dimensions (x, y, z) of a building structure enabling stakeholders

to visualize a building's structure in 3 dimensions even before the project is started. It enables all the stakeholders to collaborate effectively for modelling and solving typical structural problems. Also, as everything is stored at a central location, it becomes easier to resolve issues at a future stage.

4D BIM is related to planning the construction site by adding a new element i.e. time helping in scheduling data in outlining how much time will be involved in the completion of the project and how will the project evolve over time.

5D BIM includes budget analysis and cost estimation and is used where such analysis is required from the beginning of any project. It enables project promoters and owners to analyze the costs to be incurred over time in the project activities.

6D BIM helps to analyze the energy consumption of a building and find out energy estimates at the initial design stages to predict energy consumption requirements in more accurately way.

7D BIM (Fig. 4) includes operation and facility management. It also tracks important asset data such as its status, maintenance/operation manuals, warranty information, technical specifications, etc. to be used at a future stage.

Now, even 8D BIM is also available which includes safety also.

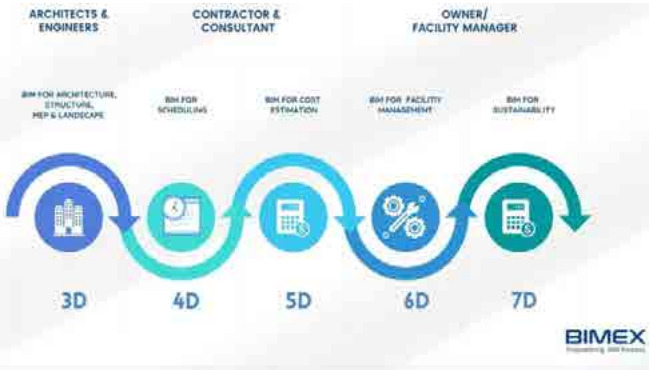

Fig. 4: BIM Levels

OBJECTIVE OF CDE AND BIM

The objective of CDE and BIM is identification of disruptions and their timely removal in the project management, effective monitoring of the project, and improving quality of construction and services with timely construction in cost effective manner.

Data

There are two types of data, known as primary and secondary data. Primary data refers to the first hand data collected by the researcher himself. Secondary data means data collected by someone else earlier. Therefore, a researcher knows about the accuracy of the data while secondary data are assumed to be correct. CDE being the depository may have primary and secondary data both however the purpose of CDE is utilization of data by someone else who has not collected the data i.e. using secondary data. Suppose, geotechnical consultant has submitted data related to the site and someone else is making their use, accuracy will depend how accurately geotechnical consultant has collected them. In case, the data collected by the geotechnical expert has inaccuracy, the design by other consultant will also affect his or her design.

In any project, accountability is fixed in case of failure. Therefore, all those connected with the failure are likely to be made responsible. Thus, every stakeholder has his or her own data and drawings and is made responsible for the same. Many times, the data are not even shared due to this fear. Success of CDE therefore depends upon accuracy of data and it is expected that every stakeholder performs his or her duty with accuracy.

Some of the stakeholders in a project do not want to share the details for use of others like an architect may not desire to share his or her design in Autocad form so that other stakeholders do not make changes. Similarly, a structural designer may not share design data. Therefore, data available will have applicability to a limited extent. However, even if non-editable data are available in CDE, these are still useful for the stakeholders. Another advantage is that these data are available for a longer period without any damage as hard copies of data generally get damaged or misplaced in long run.

CDE will require additional services of the data keeping officials in electronic form hence chances of data hacking cannot be ruled out hence data security is also essential. Thus, CDE has its cost. One must understand the concept of data, information, knowledge data security and as such CDE should not be made a repository of essential and non-essential data.

CONCLUSION

Common data environment is gaining importance due to complexity of projects nowadays. Due to large number of stakeholders working globally, data are to be stored centrally and shared even on real time basis in a project which is possible only through CDE.

BIM and project management have become subjects related to owners, financiers, designers, supervisors, vendors, engineers, contractors and facility managers hence availability of data at a central place has become essential making CDE a necessity in large and complex projects.

BIM saves time and money and timely cautions to the stakeholders to identify clashes of the services thus enabling stakeholders to take corrective actions. CDE supports BIM.

Success of CDE depends upon the accuracy of data deposited by various stakeholders.

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COMMON DATA ENVIRONMENT FOR INFRASTRUCTURAL PROJECTS MANAGEMENT- A CONCEPT NOTE FOR THE FUTURE PROJECTS

KAUSHIK BANERJEE* **AND ARUNAVO GUPTA****

Abstract

Common data environment for infrastructure projects management is a gen "z" concept in the field of project management. Now-a-days any mega project deals with plethora of disciplines. Architecture, civil, mechanical, electrical, instrumentation, social and environment every discipline has its stake but on top of it audit, arbitration and legal issues play a major role in terms of propriety, accountability, total quality management and finally a considerable amount of sustainability. So starting from the scratch till its operations a project passes through its phases wherein all the factors and issues of different branches of disciplines are encountered by the project managers.

The objective of this paper is to provide a Project Manager, the philosophy of collaboration and assimilation of multiple disciplines and flow paths to retrieve and apply the relevant data while facing the challenges and issues during a project management. This paper deals with the concept of integrating each and every discipline considering its digital (software part) and analogue aspects with sharing of past expertise and experiences in a common data environment and their implementations in a holistic manner, the ultimate goal is to streamline and optimize Project Management by integrating all task information into one common data environment.

INTRODUCTION

We do not plan to fail rather we fail to plan and this failure or weakness in the planning stage cost us lot of trouble and issues in the later stage of a project. Nowadays every project faces challenges of legal battles, arbitration and audit observation, cost overrun and time overrun. Lot of factors come into play and complexities of a project management is also responsible for the shortage of success rate of a project. Big organisations like NHAI are struggling with huge burden of arbitration and court cases. Sometimes the amount is sky high, which has serious impacts on the organisation's economy and national economy in turn. In all the projects we see lot of audit paras; in a case study in PWD, West Bengal it is seen that almost 250 audit paras are outstanding. The National Highways Authority of India (NHAI) has settled arbitration claims worth over Rs 13,000 crore through conciliation since FY 18. In the projects of PMGSY tons of audit paras have been raised by the Auditor Generals of respective states. Contemplating on these issues and to keep pace with the modern day advancement of project management, it appears to be essential that Common data environment repository for specific projects may be created and consulted before taking decisions for project approval. This paper deals with the plethora of aspects of mega projects, stake holders of a mega project and the need and proposal to integrate the project information in a common data platform.

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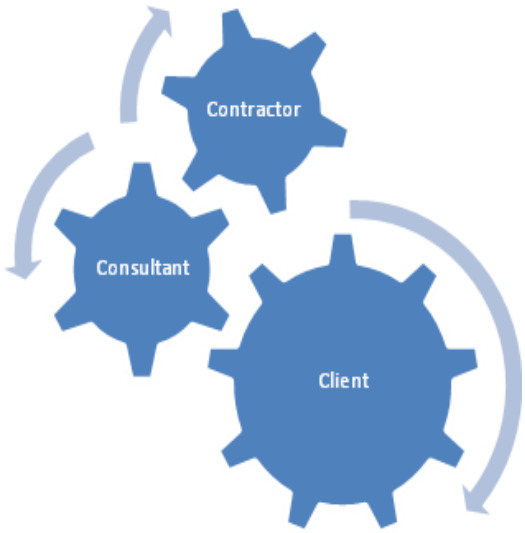
AIMS AND OBJECTIVES

A symbiosis or an ecosystem of data sharing for the project implementation, monitoring etc between 3C's – Client, Consultant and Contractor is the central objective of this paper and under this umbrella we would like to accommodate other activities in a common platform of information sharing.

- Creation of data library reviews of past projects.
- Creation of data in common format and inter-operability of data
- Data matrix, data management, data retrieval,

project progress monitoring in holistic manner.

- App based monitoring and integration with main data centre.
- Common platform for technical and non technical inputs and outputs



Client-Consultant-Contractor (3C's) symbiosis

- Audio visual documentation facility.
- Incorporation of big data handling softwares with the BIM
- Benefits like Milestone alarm opportunity through Artificial Intelligence etc.to be developed.
- Embedded help centre for technical queries.
- Integration of existing available BIM philosophy to a wider platform by integrating other non technical and administrative modules in digital platform.

Success of any project without time and cost overrun and with transparency can be achieved with CDE library. Most of our project face lot of challenges since we do not consult our past experiences. A common data environment library should have previous records of audit paras and arbitration histories, there should be a detailed study of audit replies and arbitration proceedings on the basis of such available records we may create a robust planning for any future projects. It may be deemed to play the role of Artificial Intelligence (AI).

OVERVIEW OF PRESENT AVAILABLE CONCEPTS

A common data environment (CDE) is a single platform or group of integrated IT solutions which provide a centralised repository for the collection, management and dissemination of project and asset information through a managed process. Put simply, a CDE is a collaborative environment where all stakeholders on a project or asset work on and share information. The CDE is essential for the effective and efficient implementation of BIM processes and technologies. In this manner ultimately built assets and projects are delivered on time, within budget, and to standard. The CDE represents both the CDE solution – a group of integrated IT systems – and the CDE workflow – a controlled gated process for information development and exchange as well as to enable faster, easier, and more accurate decisions to be made by stakeholders across the asset lifecycle. ISO 19650 and the CDE workflow requires the interoperability of information across different systems, disciplines, and parties. This is because the CDE solution may not be a single product, but rather a group of integrated and interconnected IT systems. Different CDE solutions may also be used at different stages throughout the asset lifecycle. ISO 19650 recommends the use of open data formats wherever possible to ensure the interoperability of information. An example of open data formats could include MP3, PDF, XML, and IFC file types. While proprietary data is restricted to specific software solutions.

STEP (Systematic Tracking of Exchanges in Procurement) is an online system that helps the World Bank and Borrowers plan, record, and track key stages of the procurement process under Investment Project Financing (IPF) projects. It is designed to help Borrowers achieve "value for money" in procurement by transforming data into knowledge, speeding up the procurement process, and improving accountability, efficiency and transparency. It streamlines and automates some stages of the procurement process and enables monitoring and reporting.

KEY FEATURES

- Cover the end-to-end contract implementation cycle from contract signing to contract completion and consolidates contract management records

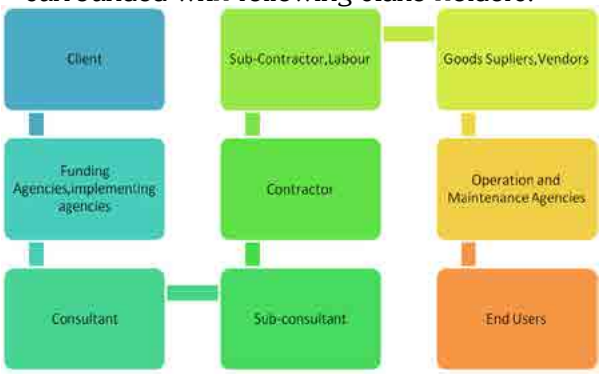
- Require assignment of a contract manager for each contract
- Support borrowers to develop a Contract Management Plan to track progress during implementation including the following:
  - Key contract deliverables and their expected dates;
  - Planned payments and their due dates;
  - KPIs where applicable;
  - Planned dates for major milestones and progress against them,
- Provide automated alerts/reminders to borrowers and task teams of upcoming or overdue milestones. Support better tracking of contract variations, claims and contractual disputes including their resolution. Provide dashboards and contract and project level reports on progress with contract implementation.

STEP Advantages:

Procurement Planning & Tracking	Streamlining & Automation	Monitoring & Reporting
Procurement planning	End to End Processing	Portfolio Management
Activity Tracking	No Objection System	Project Status Review
Implementation Road Map	Document Management	Performance Reporting
Notification & Alerts	Automated Publication	Business Intelligence

- **Stake Holders :**

  In any infrastructure project we are broadly surrounded with following stake holders:



- **Components :** Component matrix of CDE 's are :

Technical Matrix	Financial Matrix	Social and Environmental Matrix	Financial Matrix
Responsibility Matrix	Procurement Matrix	Operation and Maintenanace Matrix	Non-Technical Matrix

These are the overall aspects to take into account when choosing our CDE:

- Access and viewing permissions according to users
- Interactive visualization platforms (excels, pdfs, models, plans…).
- Collaborative working.
- Versioning repository.
- Organization of information through folders or metadata.
- User friendliness.
- Approval/rejection of drawings or deliverables.
- Contract Management.
- Price of the platform.
- Safety and data protection.

These are some of the most popular Common Data Environments:

- BIM 360 – Autodesk
- Connect
- Project Sight
- Viewpoint – Trimble
- Aconex – Oracle
- Project Wise – Bentley
- Think Project
- Dalux
- usBIM.platform – Acca Software

The choice of a CDE is an important milestone for any organisation as it will be there for the duration of the project. It will be the place of exchanging information with other companies and will be used on a daily basis by the team members. For this reason it is recommended to incorporate a training program to get the most value out of it.

Sl No	Data Type	Indicative Detail at the back end
1	General data:	Area:- (Total area, Mouza details, Land Records), detail survey data, Population (Male, Female, age group distribution, religion distribution, literacy distributions, Employed, Unemployed, self employed)Per capita Income, Political Parties, Administrative divisions (District, Block, Subdivisions),Law structure, Occupation data
2	Demographic data	Thematic Maps, if available
3	Health data	Hospital (Private & Govt.);Primary Health Centre; Telemedicine Centre; Doctors Chambers (Allopath, Homeopaths etc); Medicine shop
4	Education	Schools (Nursery, Primary, Secondary, Higher Secondary, College, Madrasha); Teachers (Male, Female); Students (Boy, Girl); Course Curriculum/Boards; Technical Education/Skill development facilities; Music, Dance, drama learning facilities; Marshall Art learning facilities; Body Building facilities; Sports education
5	Infrastructure	Buildings (Govt buildings, Private buildings) Roads; Pucca Structure; Kuchha Structure; Multipurpose Cyclone Shelters; Electrical Tower; Mobile Tower; Watch Tower; Electrical poles; Transformer; Early Warning Tower; Rain Gauge station, Weather Cock, Met station; Overhead Tank; Cold Storage; Petrol Pump; Ration Shops; Krishak Mandi, Market Building; Godown; Bank and Financial Institution; dilapidated structure
6	Agriculture	Total Cultivable Land; Non Cultivable Land; Season Period; Type of Crops; Crop statistics (Quantum of Production and Quality, quantity excess, Quantity storage)
7	Meteorological data	Rain fall data, Seismic Data, Cyclone data etc
8	Commerce, Industry and Business	Detail relevant information.
9	Environmental & Social Data	Types of Ecosystem Present; Flora and fauna, Sustainable development of the area; Climate Change Resilient society; High Air quality standards; Land Fertility maintenance; Population balance; Very High Health quality index; Very High literacy Index; Very Low Carbon footprint; Excellent Tourism Opportunity; Zero waste Community
10	Forest and Social Forestry data	As a supplement of environment, climate change and sustainable development data
11	Animal Husbandry data	Data of cattles, other animals
12	Disaster Management data	Records of all hydro -meteorological disturbances
13	Fisheries	No of Fisherman; Pisci culture data
14	Historical data	As applicable for the project.
15	Transportation data	Motor (Two, Three, Four Wheeler, Private, Govt, Bus, Truck); Rickshaw, Toto(Manual, Battery driven); Fuel Availability; Pollution due to transportation
16	Tele-Communication data	Its relevance with the project.

- **Need for CDE with a case study:**

Systematic tracking of exchanges is tailor made software of World Bank which is used to track the road map of a task under a big, major or mid size project. A dynamic data input is necessary for the software to provide output efficiently. In this software a multilevel approval system is involved which in turn brings a item of responsibility. Here below we have sorted out information data base indicators before stepping into a project preparation. Common Data Environment platform or activity or input of a project should begin from this point onwards.

DATA AND STATISTICS

Apart from technical data we may see how other social and environmental data is essential for a developmental projects. Real data collection is important if we list out data variations for a small projects of developmental activity of a project.

Sl No	Type of Archive	Remarks 1	Remarks 2
1	General Project information	Detail records of a project, like inception reports, feasibility study, LA records, DPR, Quality control etc. Time overrun and cost overrun data	To use in similar type of projects, To asses success and failure rates of a project
2	Audit Para	Audit observations, replies, etc	To review and making decisions for future projects
3	Legal data	Legal issues occurred before, during and after the project	To review and making decisions for future projects
4	Arbitration data	Arbitration battle between the parties and its record upto award stage	To review and making decisions for future projects
5	Financial detail data	Financial allocation, fund flow pattern, funding agencies, repayment conditions and financial management data	To use in similar type of projects, To asses success and failure rates of a project
6	Manpower data	Manpower consumption, issues, rates etc	For review and essential for budgeting
7	Resource related data	Resource consumption, issues, revenue records	For resource planning
8	Technical manpower, resource personnel directory, technology related data	References of all such technical data with detail used in specific purposes	To use in similar type of projects

COMMON DATA ENVIRONMENT LIBRARY

Our idea of CDE library is an extension of modern BIM concept wherein a library would be embedded in the system of project library where previous experiences would be shared or stored for consultation. Here the different type of data may be in the library which can be retrieved as per need from the archive. The core part of the entire system is the data repository, which describes the technical space in which all data is physically stored. Since all the information created during the BIM processes over the lifecycle of the building project is stored in the environment, a presumably large amount of data should be considered when establishing a CDE. There are no specifications that shows in detail where data should be precisely located or which technology is to be used. A central criterion, however, is that data should be accessible at any time from any location for the involved stakeholders. For this reason, technologies that, make the content easily and directly accessible via the internet (especially cloud systems) should be considered as technological foundation for this approach.

PROPOSED MODULES :

Implementation strategies for CDE

- Information Containers
- Model Federation
- CDE Workflow
- CDE Metadata

On the basis of above software architecture let us try to accommodate the following broad classification of module which would be on the output end of the software.

- Architectural Module
- Civil and structural Module
- Field Surveying module
- Quantity surveying, specification and estimating module
- Financial module
- Procurement module
- Audit and cost control module
- Legal Module
- Environment, sustainability and climate change module
- Social Module
- Safety module
- Overall parameter based project monitoring module
- Help and data centre module

PROPOSAL FOR NEW PROJECT MANAGEMENT SOFTWARE

In this paper we would like to build a philosophy to create a software which would be used to work in unison with BIM protocol, BIM execution plan, model federation, etc. along with the idea of online system of tracking and monitoring of road map of project management and financial management as well.

A new platform would have CDE library, all the modules of project management, data exchange facility, new information creation facility, dynamic input of project data, common dashboard for different hierarchy level, Enterprise resource planning for the organisation integrated with BIM, All the features under one click, Advanced file sharing, inter-portability of common file type.

An integration of all available related software's linked with the online project management (Project Road map and Milestone based) on CDE platform

Drafting tools	Structural Software	Project Management Software	Financial Software	Big Data Analysis Software	Basic Office Tools
Autocad	STAAD, Etabs	Primavera/MS Projects etc.	Tally etc,	Hadoop, Tablau, Looker etc	Word, Excel, MS Power Point, Adobe Acrobat etc. (PDF Files)

is the concept of this paper. Related softwares are:

These softwares may work simultaneously with BIM on CDE platform.

Brief guidelines of the architecture for the proposal

In a BIM based construction project several "project participants" create digital representations of a construction or Infrastructural facility using

different authoring tools in a collaborative process. During the planning and operation of a project participants exchange various information from different domains based on procedures agreed upon. Practical experience has shown that direct use of single shared model is not recommended for a number of reasons. Presently the principle of domain specific federative model is preferred over any other options. This method gives right to the model author full access to the domain specific sub-model for which they are responsible. Each model is an individual aspect of the overall model and usually called a discipline or domain specific partial model. According to this federated mode; approach each assigned author maintains their domain specification model exclusively so that the responsibilities for and authorship of building elements as well as any subsequent changes are managed unambiguously. However, this results in an enormous number of interfaces and data transition points, which must be coordinated to maintain the consistency and validity of the overall model.

A primary challenge of a BIM-based project is, therefore, to manage the information processing and exchange processes described above during the lifecycle of the construction project. To address this, procedures for structuring, combining, distributing, managing and archiving digital information must be set up and technically supported within a framework for integral model-based project management. It is widely recognized that for the implementation of BIM-based projects and the related collaborative processes, digital collaboration platforms are highly suitable. An essential aspect of the data management of digital construction process is the centralization of data and information as a basis for all collaborative process. ISO/DIS 19650-1(2017) (which is mostly based on the British PAS 1192-2, 2014) specifies the characteristics of the technical solutions of this requirement the Common Data Environment(CDE). ISO 19650 specifies two parts of the BIM-based execution of construction projects: project management and information delivery. Project management describes all process steps necessary to set up a BIM project, including the definition of the Employer Information Requirements (EIR) and the tendering and contractual process as well as the preparation of the BIM execution Plan(BEP). Information delivery in turn, describes all steps that are necessary for model creation and delivery, including the use of a Common Data Environment (CDE).

All "project participants" retrieve input data from the CDE. The CDE store all domain specific partial models and documents which are necessary for the coordination and CDE represents a layered structure composed of the individual technical elements(based on PAS 1192-2,2014) for execution of a project.

DATA STRUCTURING

In addition to the data repository, the structure of the stored information is essential part of the CDE. This structure must be agreed upon at the beginning of the project and should be updated and reviewed on in an ongoing basis-a requirement that is frequently made a contractual obligation. Based on the complex characteristics of infrastructural projects and the identifiable resources, BIM data can be structured in various ways. Commonly used structuring categories might be divided into technical and functional aspects. Technical categories refer to handle data and can be divided into different levels of aggregation (models and documents and collection thereof, elements group or single elements, element attributes and property sets) The technical structuring approach comprises of:

Domains (e.g. Concrete Works, Earth Works, Finishing Works, Layout etc.).

Phases (The temporal development of project with corresponding increasing amount of information and planning status).

Zones (spatial structure of building or other structure)

Systems (aggregation of building fulfilling a common function e.g building supply system).

BENEFIT OF CDE, ROLE OF GOVT.

As envisaged in STEP by World Bank, the software enables a holistic approach of systematic tracking of exchanges. This proposal would like to focus on the Government projects like PMGSY,IAY, RIDF,NHAI road projects and projects of other big organisations where ERP of the organisation may be integrated with BIM and references of previous projects can be consulted before planning. Data transparency, visualisation, progress monitoring through Application based project monitoring system and its

dynamic input to main data server may be a default facility of the system. By integration the project inputs with ERP of the organisation approval in terms of both technical and non technical activities can be made easier and faster. Protection from cost and time overrun, Risk analysis and reduction, forecast of challenges can be handled early. The first benefit of a CDE that can be recognised is certainly the fact that everyone has an insight into the latest versions of documents, drafts and models. In that way, searching emails and taking phone calls are kept to a minimum. Related to that, having a centralised system improves the collaboration between internal and external stakeholders and gives a clear view on the project. The risk for the investor and all team members is reduced to a minimum which enables continuous improvement during each project phase. For each person or team involved, appointing party or third party acting on their behalf, which is responsible for managing a CDE, can set up different security settings and individually allow which data will be accessible for each team. With this approach, security of data could be controlled and managed easily. If we use these states in the form of metadata, they will define levels of model maturity. The "Project Information Manager" needs to ensure that the system used for sharing models contains the following codes and descriptions to clearly identify the 'Purpose of Issue' for model documents.

CONCLUSION

This paper is mainly focusing on Govt. projects of different sizes. No Govt. project should be treated in an isolated manner, especially big projects because each and every project contributes an experience and maturity towards project management. General and all round elements of a project are often overlooked in the broader perspective of project management. In the common data environment platform each and every detail of a project would come under the purview of project management. Big data analysis tools are incorporated as well in the system to generate conclusive outcome of project objective and retrieval of data and stats as and when required. A common data environment website for projects is also proposed in this paper. Within the ambit of this paper we expect in a nutshell, an idea of new look of CDE in wider arena.

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COMMON DATA PLATFORM IN PROJECT MANAGEMENT THROUGH BIM

USHA BATRA*

Abstract

A common data Platform/ environment is a digital information platform that centralizes project data storage and access. It is an essential part of any construction project. CDE provides a single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents. Creating this single source of information facilitates collaboration between project team members and helps to avoid duplication and mistakes.

BIM is one such software/technology which fulfills this requirement along with many other additional benefits. With BIM technology, an accurate virtual model of a building is digitally constructed. The building information model when completed, contains precise geometry and relevant data needed to support the design, procurement, fabrication, and construction activities required to realize the building. After completion, this model can be used for operations and maintenance purposes. It also facilitates more accurate estimates, determining the correct amount of materials needed which substantially increases the accuracy of overall project estimates. BIM as a centralized repository allows all stakeholders to access the same version of data which mitigates the risk of poor communication.

INTRODUCTION

A common data Platform/environment i.e. CDP/ CDE provides a single source of information for any given project, to collect, manage and disseminate all relevant approved project data/documents. Creating this single source of information facilitates collaboration between project team members and helps to avoid duplication and mistakes, reducing the time and effort required to check, version and reissue information, enabling reuse of information to support construction planning, estimating, cost planning, facility management, and many other downstream activities and reducing the time and cost of producing coordinated information.

It is also known as Integrated Project Delivery (IPD), a growing approach for delivering projects that unifies different disciplines efforts and integrates all parties including project managers, designers, engineers, system and practices into a collaborative process. Combining and unifying detailed information from all parties into an integrated model improves the productivity of project team and facilitates its management. The project team can effectively track, assess and review the project, make decisions when necessary, resolve conflicts and discrepancies and execute the project successfully. CDE/IPD is an integrated approach for project management and BIM is the technological interface that facilitates this process.

BIM can be defined as a reliable, digital, 3D, virtual representation of the project to be built for use in design, decision making, construction scheduling and planning, cost estimates and maintenance of construction projects. It is computer aided modeling technology for the purpose of managing information of a construction project focusing on production, communication and analysis of building information model. BIM's capabilities are vast and varied. The main purpose of BIM is communication improvement, especially between two of the main parts of any construction related project, the design team and the construction team. BIM as a centralized repository allows everyone involved in a construction project to access the same version of data which mitigates the risk of poor communication.

**Former SDG, CPWD*

BIM- AN EFFECTIVE AND POWERFUL TOOL IN PROJECT MANAGEMENT

BIM is considered as an effective and powerful tool (Fig.1) in project management in the construction industry. BIM creates a common language between all parties and system divisions in a project and make them an integrated team. Integration management is the first area of Project Management, which has the same function as the BIM (Fig.2). BIM integrates the documents, plans and efforts of all parties involved on a project. BIM has the capability of managing time and cost or what is generally called 4D and 5D. This is similar to project cost and time management areas in PM standard. Clash detection in BIM acts as a quality process which visually recognizes, modifies and analyzes the soft and hard clashes. Collaboration and team building in BIM is what human resource management considers as a project management area. In addition, changes in any item can be easily reflected in cost and time and work needed for its procurement.

Fig. 1: BIM – Effective & Powerful Tool

Fig. 2: Mode of PM and BIM

Fig. 3: Virtual Model

With BIM technology, an accurate virtual model of a building is digitally constructed as shown in Fig 3.This model, known as a building information model (BIM), can be used for planning, design, construction, and operation of the facility. It helps architects, engineers, and constructors visualize what is to be built in a simulated environment to identify any potential design, construction, or operational issues. When completed, the building information model contains precise geometry and relevant data needed to support the design, procurement, fabrication, and construction activities required to realize the building. After completion, this model can be used for operations and maintenance purposes also.

Building information model of the facility at the early design phase is most helpful to determine the best building orientation and evaluate various skin options such as masonry, curtain wall, and window styles in exterior as well as interior e.g. tile / stone / wood flooring or cladding etc. It is most helpful for clients and all other stakeholders as it enables them to visualize the complete building as well as each and every space / room/ facility individually including furniture layouts from each and every angle, in the design stage itself being a 3D model.

Thus, building information model characterizes the geometry, spatial relationships, geographic information, quantities and properties of building elements, cost estimates, material inventories, and project schedule. The model can be used to demonstrate the entire building life cycle.

BIM – COLLABORATION AND TEAM BUILDING

As mentioned earlier, BIM encompasses all aspects, disciplines, and systems of a facility within a single, virtual model (Fig. 4) allowing all design team members (owners, architects, engineers, contractors, subcontractors, and suppliers) to collaborate more accurately and efficiently constantly refining and adjusting their portions according to project specifications and design changes to ensure the model is as accurate as possible before the project physically breaks ground.

BIM also supports the concept of integrated project delivery, which is a novel project delivery approach to integrate people, systems, and business structures and practices into a collaborative process to reduce waste and optimize efficiency through all phases of the project life cycle.

BIM – LODs

There are different LODs i.e. Levels of detailing e.g. 100, 200, 300, 350, 400, 450 and 500 as shown in Fig 5. BIM 100 is basically a 3D architectural design model, 200 has additional MEP line details, 300 is design development and clash detection, 350 is with addition of BOQ, 400 includes GFC drawings, 450 includes shop drawings for fabrication and 500 includes as built drawings.

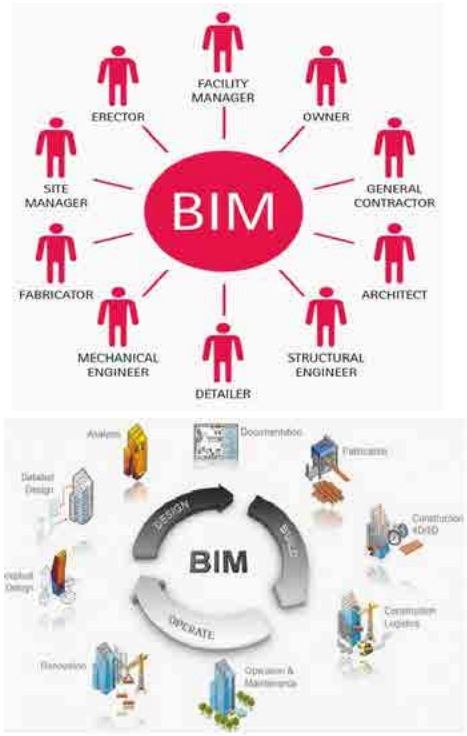

Fig. 4: BIM encompassing Various Stakeholders

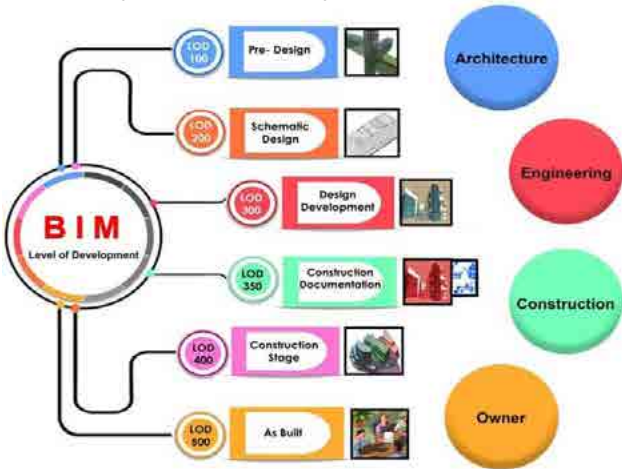

Fig. 5: Levels of Detailing

INFORMATION LANDSCAPE AND BIM

One of the targets of BIM is to form a single unified source of information for the design and the construction process of the project in question – including asset information, architectural designs, structural information, and more.

There are no file duplicates since BIM platforms allow specialists to work on the project at the same time, implementing their changes as they appear. There is no miscommunication regarding the state of the project, it's easier to administer the entire process, and the risk of clashes is much lower.

This is "true BIM" – a user-friendly information landscape that is transparent and coherent, with all the project's participants having access to it.

APPLICATIONS OF BIM

A building information model can be used for the following purposes:

- Visualization: 3D renderings can be easily generated in house with little additional effort.
- Fabrication/Shop Drawings: It is easy to generate shop drawings for various building systems e.g. the sheet metal ductwork shop drawings can be quickly produced once the model is complete.
- Code Reviews: Fire departments and other officials may use these models for their review of building projects.It saves time on multiple checking for code compliance and allows for a more efficient design process since mistakes cost time and money.
- Cost Estimating: BIM software has built-in cost estimating features. Material quantities are automatically extracted and updated when any changes are made in the model.
- Construction Sequencing: A building information model can be effectively used to coordinate material ordering, fabrication, and delivery schedules for all building components.
- Conflict, Interference, and Collision Detection: As BIM drawings are created to scale in 3D space, all major systems can be instantly and automatically checked for interferences e.g. this process can verify that piping does not intersect with steel beams, ducts, or walls.
- Forensic Analysis: A building information model can be easily adapted to graphically illustrate potential failures, leaks, evacuation plans, and so forth. This feature may not have been used as yet.
- Facilities Management: Facilities management departments can use it for renovations, space planning, and maintenance operations.

Key benefit of a building information model is its accurate geometrical representation of the parts of a building in an integrated data environment .Other related benefits are as follows:

- Faster and More Effective Processes: Information is more easily shared and can be value-added and reused.
- Better Design: Building proposals can be rigorously analyzed, simulations performed quickly, and performance benchmarked, enabling improved and innovative solutions.
- Controlled Whole-Life Costs and Environmental Data: Environmental performance is more predictable, and lifecycle costs are better understood.
- Better Production Quality: Documentation output is flexible and exploits automation.
- Automated Assembly: Digital product data can be exploited in downstream processes and used for manufacturing and assembly of structural systems.
- Better Customer Service: Proposals are better understood through accurate visualization.
- Lifecycle Data: Requirements, design, construction, and operational information can be used in facilities management.

ADVANTAGES OF BIM

- 2D drawings generation which are required for construction, earlier collaboration of multiple design parties, cost estimates extraction during the design stage and energy efficiency and sustainability improvement are advantages in the design phase of a construction project.

- Synchronizes design and construction planning, detects errors and omissions and implements lean construction techniques in construction phase.
- Improved productivity with less re-work, conflicts and changes.
- Faster project delivery.
- Better project quality and performance.
- Reduced wastage and construction cost.
- New revenue and business opportunities.
- Enables better facilities, operation and management in post construction stage.

TECHNICAL ASPECTS OF BIM

Building Information Modeling has some sophisticated technical aspects which can greatly facilitate project management.

- **Clash Detection:**

  The inconsistencies in the geometrical designs of the various disciplines of a building are the most commonly seen problem in an (AEC) Architecture, engineering and construction industry. This happens because of an overlap between the different plans. The only feasible solution for this issue would be to use BIM and bring the plans together in a cloud and detect any discrepancies and make the necessary changes (Fig 6).

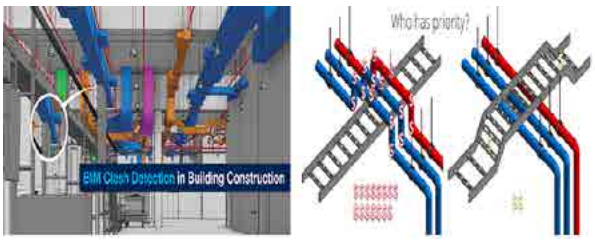

Fig 6: Clash Detection

- **Constructability:**

  Building Information Modeling provides a platform to carry out constructability reviews and monitor constructability.

- **Building Information Modeling allows for a better Analysis:**

  BIM allows engineers and designers a better visual analysis of a building and facilitates better decision making. Starting from the energy consumption details to optimum lighting conditions needed (Fig 7), BIM helps find better solutions such as changing materials and orientation, mass and space, etc. for every problem.

- **4D & 5D Modelling:**

  One of the unique features of Building Information Modeling is that it can offer 4D &5D modeling (Fig. 8). A 4D model allows an engineer to evaluate the progress of a construction project w.r.t. time and have a clear understanding of the project phases e.g. Linking of Primavera/MS Project with BIM. 5D BIM models allow cost evaluation of a project and can help in determining the lowest cost solutions. Essentially, BIM facilitates simulation of various alternatives for a construction project and helps project managers and executives to reliably predict the consequences of their decision. 6D is for energy analysis and 7D is for facility management and maintenance but are rarely used.

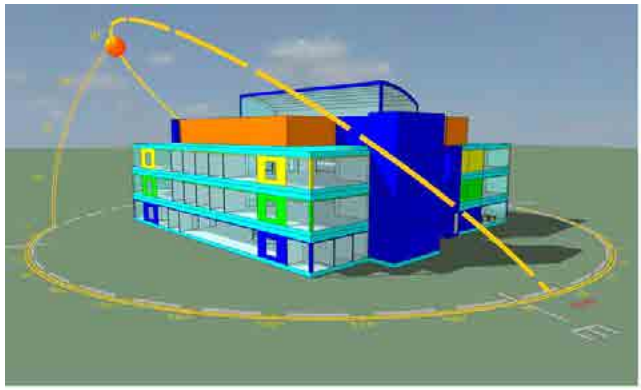

Fig. 7: BIM for Optimum Lighting

Fig.8: BIM Models

- **Quantity Take-off:**

  Quantity takeoffs available in a BIM model can be of assistance to the project teams and managers in analyzing their decisions and facilitate a clear and reliable insight to various alternatives in the design phase or even throughout the project lifecycle. Since there is a possibility of integration between the BIM model and a database containing cost estimation, an accurate estimation can be obtained faster.

- **Integration, Collaboration and Communication:**

  Project team can interact with a composite / unified model made from amalgamation of model of various disciplines. BIM can coordinate the design, analysis and construction activities of a project and hence results in integrity of the project (Fig. 9). All disciplines working on a unified model as a team results in effective collaboration. Modification and analysis of data in unified model improves communication between all stakeholders and curtails disputes among them putting the project on fast track.

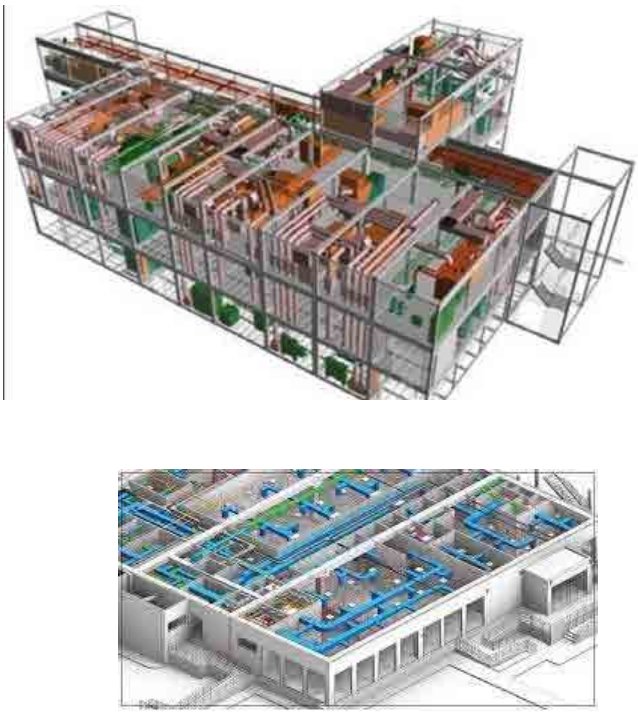

Fig. 9: BIM for Integrity of the Project

FLEXIBILITY AND NEW OPPORTUNITIES WITH BIM

Making information about the project available for all of the project's participants makes it easier for project managers to direct and manage all the teams. The entire process is made faster and less prone to errors as the specialists can deploy their expertise whenever it is necessary, making the entire project less segregated and disjointed.

Technical challenges can also be worked on in real-time by the design teams, making them aware of the structural capabilities of the project so that newer solutions can be developed or older ones can be adapted to the limitations. The correct usage of BIM allows different teams to continually compare their creative thoughts with the technical possibility of each one of them, making it less possible for something unrealistic to be implemented.

A unified information source allows project managers to understand the current processes better, and the same goes for design teams and construction teams. This kind of understanding makes it easier to work with prefabricated materials, experimental designs, 3D printing and other less common technologies.

BIM AND PROJECT MANAGEMENT – A SEA OF OPPORTUNITIES

With BIM, it's possible to leverage the experience of all of the different teams and specialists for the benefit of the project, even the ones that would've been disconnected from that process in any other scenario.

A complete understanding of all of the different benefits that BIM provides is essential for all the stakeholders. It's possible to completely transform the way all teams work together – with higher efficiency and more creativity as a result.

That's not to say that the ever-evolving technology is not included, as well. For example, there's laser scanning that can provide accurate information about live scenes and environments, and such data can be imported into BIM to act as a remote monitor of the construction progress.

While BIM's main driver is collaboration and communication between different teams, it would be much harder to reach the intended results

without a project manager who understands all of the potential benefits and possibilities that BIM could provide. It's a part of the project manager's job to spread information about the changes that come with implementing BIM project management and how it can be utilized in different ways.

PROJECT MANAGEMENT IMPROVEMENTS THROUGH BIM

There are several different areas in which BIM could significantly influence the flow of operations, thus increasing general productivity, among other parameters.

- Better Communication and Collaboration Efforts; A visual reference is essential to improve cooperation between different parties involved with the project. This also includes the ability for different teams to share their insights and work together to improve the project's end result.
- Decreased Costs of Construction; Risk mitigation, fewer errors and accidents, reduced insurance costs, prefabrication areas detection – these are just some of the advantages that BIM offers, resulting in the overall decrease of the construction costs.
- Full Visualization of the Project; The ability to offer all of the parties involved an accurate 3D representation of the entire project- interiors and exteriors is a goldmine of effectiveness, making it much easy for clients to figure out possible improvements at the design stage itself.
- Improved Productivity; Better planning and scheduling is one of the methods of BIM to affect the overall productivity of the construction team – with less wasted time, more defined stages of construction, and figuring out possible prefabricated parts of the building beforehand.
- Better Task Scheduling; Another consequence of the visualization as an advantage is the ability for the different teams to interact with each other more efficiently, resulting in general better organization for all kinds of work within the project.
- Heightened Clash Detection; The integration of different plans from different parties into the same system allows for a significant improvement in the clash detection so that changes to the project could be made before the construction begins in the first place. Some of the more apparent problems could even be detected automatically by the system itself.
- Better Building Quality; An obvious conclusion of the general efficiency increase, improved project management, is the higher quality of the end product.
- 4D & 5D Modeling; 4D – project progress evaluation, 5D – cost evaluation.
- More Accurate Estimates; Determining the correct amount of materials needed substantially increases the accuracy of overall project estimates.

CASE STUDIES

After gathering data on 32 major projects, Stanford University's Center for Integrated Facilities Engineering reported the following benefits of BIM (cited in CRC Construction Innovation 2007):

- Up to 40% elimination of unbudgeted change,
- Cost estimation accuracy within 3% as compared to traditional estimates,
- Up to 80% reduction in time taken to generate a cost estimate,
- A savings of up to 10% of the contract value through clash detections, and
- Up to 7% reduction in project time.

The future of BIM is both exciting and challenging. It is hoped that the increasing use of BIM will enhance collaboration and reduce fragmentation in the Construction industry and eventually lead to improved performance and reduced project costs.

CONCLUSION

- BIM creates a common language between all parties and system divisions in a project and makes them an integrated team in a transparent and coherent manner, with all the project's participants having access to it, ensures faster project delivery, better project quality and performance, reduces wastage and construction cost.

- BIM is most helpful for clients and all other stakeholders as it enables them to visualize the complete building as well as each and every space individually, to make right decisions at the design stage itself.
- 2D drawings generation, earlier collaboration of multiple design parties, cost estimates extraction during the design stage and energy efficiency and sustainability improvement are some of the advantages of BIM
- BIM Synchronizes design and construction planning, detects errors and omissions and implements lean construction techniques in construction phase.

Knowledge of REVIT and BIM is must for making utmost usage of BIM and expediting the whole process of BIM. All Government departments must start using REVIT for making the project completely understandable by all the stakeholders at the design stage itself.

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COMMON DIGITAL ENVIRONMENT FOR INFRASTRUCTURE PROJECT

CASE STUDY : GATI SHAKTI NATIONAL MASTER PLAN

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Abstract

Multiple on-going infrastructure projects need common digital platform to avoid duplication of works and enhance transparency. Such system provides strong base in faster decision making process. The Gati Shakti Master Plan has been developed on GIS platform wherein data on specific action plan of all the Ministries/Departments is incorporated within a comprehensive database. Further, this database of ongoing & future projects of various Ministries has been integrated with 200+ GIS layers. It uses geo-mapping and real-time data in one centralized portal with real-time updation. Similarly, the preparation of base maps and Master Plans of towns and cities on GIS platform at the scale of 1:4000 under AMRUT Sub-scheme are also useful for better integration and implementation of urban development plans.

INTRODUCTION

Infrastructure projects are generally capital intensive and exclusive but always crucial and vital for economical and social development of the cities and the regions. These projects have both tangible and intangible benefits to the inhabitants. Contrarily, these projects have positive and negative impacts on the surrounding environment. In urban areas, major and multiple infrastructure projects are undertaken which have large investments, complexity in execution due to more than one executor, extensive impacts on environment, economy and ecology. Further, these projects also affect residents and their life styles and livelihoods.

The multiple on-going infrastructure projects need common digital platform to avoid duplication of works and enhance transparency. Such system provide strong base in decision making process by the competent authorities, planning professionals, construction experts, project managers, etc.

INFRASTRUCTURE PROJECTS AND COMMON DIGITAL PLATFORM: NEED OF THE HOUR

According to the National Portal of India, (www.india.gov.in/topics/infrastructure), infrastructure is a major sector that propels overall development of the Indian economy. It ensures time-bound creation of world class infrastructure in the country. It focuses on power, bridges, dams, roads and urban infrastructure development.

By and large, infrastructure is defined as "the physical components of a basket of facilities and interrelated systems" which provide goods and services essential to enable, sustain and enhance human livings and retain the contiguous environments. Infrastructure may be composed of public and private physical structures such as roads, railways, water supply, power system, telecommunication, health system, etc. However, infrastructure is inter-related, inter-connected and overlapped areas of developments.

Now-a-days, infrastructure projects need to be designed and executed in sustainable manner. In other words, "Sustainable Infrastructures" are those which are planned, designed, constructed and implemented by considering environmental, economic and social benefits /sensitivity through minimizing water, waste and energy. Table 1 describes ongoing unique mega infrastructure projects in the country.

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Table 1: Unique Mega Infrastructure Projects in India

S.N.	Project	Sector	Description
i.	Project Himank	Road	It is ongoing project of Border Roads Organization for construction of motorable road through the glaciers in Ladakh's eastern region
ii.	Chenab Rail Bridge	Railways	It is ongoing project of Indian Railways and located in UT of J & K. The bridge will be 1,315 kilometers long at 359 meters above sea level.
iii.	Mumbai Trans Harbour Link Project	Port & Harbour	It is also known as Sewri -Nhava Sheva Sea Link Project. It is a 22-kilometer-long sea bridge and will be India's longest sea link once completed.
iv.	Navi Mumbai International Airport	Aviation	This will be the city of Mumbai's second airport and is scheduled to open in 2024.
v.	Sagarmala Project	Port & Harbour	The project intends to improve India's coastline. This will make ports and harbor operations more efficient.
vi.	Hyperloop Project	Transport	Hyperloop as a mode of transport is envisioned to travel @ 1200 kmph. Pods of hyperloop are designed to levitate. The same may be functional in country by the year 2029.

Source: collected from various sources hence represents approximate information.

Certainly, such mega infrastructure projects in the country need common digital platform to remove hindrances, speed up the progress, avoid duplication of works and completion in time.

GIS BASED MASTER PLANS FOR 500 CITIES UNDER AMRUT SUB-SCHEME: COMMON DIGITAL PLATFORM

The Geospatial technology as a tool is used for mapping of surfaces & terrains and its analysis. Some of them such as remote sensing, aerial photography, LIDAR, Drone/UAV, Global Positioning Systems , Geographic Information Systems (GIS), etc. are used in the preparation of Base Map of towns and cities. The various blue prints of developments of town and cities for next 20 years are governed by the Master plan. For preparation of Master plan, first of all updated and latest base map is required. A base map shows the existing physical pattern of the land upon which survey info analysis and planning proposal are superimposed. A base map is a base layer with geographic information that provide location references for all features that do not change such as boundaries, rivers, lakes, roads, railways networks, etc.

The formulation of GIS based Master Plan for AMRUT Cities is one of the important reforms under Atal Mission for Rejuvenation and Urban Transformation (AMRUT), which is 100% centrally funded Sub-scheme started in November 2015. The sub-scheme is envisaged as a state driven program with funding from Central Govt. with an outlay of Rs 515.00 crores. The objectives are:

- To develop common digital geo-referenced base maps and land use maps on Geographical Information System (GIS) platform using very high resolution satellite data and
- To formulate Master Plan for 500 cities that are selected as AMRUT cities.

As per update available on website, 257 towns have prepared draft Master Plan whereas Master Plan for 135 towns have finalized. The base maps of these towns and cities on GIS platform at the scale of 1:4000 are also useful for other on-going schemes such as Smart cities mission, AMRUT, HRIDAY, Swachh Bharat Mission, etc.

Table 2: Budget Components for AMRUT Sub-scheme on Formulations of GIS based Master Plan for 500 AMRUT Cities

S.N.	Sub-scheme Components	Budget Allocation (Rs. in Crore)	Actions
i.	Geospatial data creation at 1:4000 scale for 500 AMRUT towns	115.90	Generation of Base Map & Thematic Maps and Urban Database Creation at the scale of 1:4000 as per AMRUT Design & Standards.
ii.	Plan Formulation using Geospatial database	388.25	Formulation of Master Plan of city as per State Town & Country Planning Act on the GIS base map and sector-wise data analysis.
iii.	Capacity Building	10.85	Capacity buildings programs are adopted for those involved in preparation of GIS based Master Plans.
	Total	515.00	

GATI SHAKTI : NATIONAL INFRASTRUCTURE MASTER PLAN

The "PM Gati Shakti National Master Plan (PMGS-NMP)" was launched on 13th October 2021 for providing multimodal connectivity infrastructure to various economic zones. This ₹100 lakh crore mega plan was launched with a digital platform to bring different ministries together for integrated planning and implementation of projects. The 'Gati Shakti' also known as "Holistic Infrastructure Development Program" aims to improve the productivity of industries and employment opportunities.

In fact, it is a transformative approach for economic growth and sustainable development. The approach is driven by 7 engines namely: Railways, Roads, Ports, Waterways, Airports, Mass Transport and Logistics Infrastructure. The same is achieved by Sabka Prayas i.e. efforts of the central government, the state governments, and the private sector together. The benchmark of the Master Plan is to create world-class modern infrastructure and logistics synergy among different modes of movement for people, goods and services and location of projects to raise productivity and accelerate economic growth and development.

Gati Shakti Master Plan: Common Digital Environment

Under this plan, all the existing and proposed economic zones are to be mapped along with the multimodal connectivity infrastructure on a common platform. All ministries use this common platform to examine the project proposals in close coordination and collaboration with other ministries proposals both existing and proposed. The Gati Shakti program is a paradigm shift in decision making to break the silos of various departments to achieve efficient, seamless multi-modal transport network in the country. In this context, the following steps for common digital platform are used:

- GIS-based enterprise resource planning system with 200+ layers for evidence-based decision making.
- Use of satellite imagery for monitoring.
- Digitization as a tool in ensuring timely clearances and addressing potential issues in project monitoring.

The Gati Shakti Master Plan has been developed on GIS platform wherein data on specific action plan of all the Ministries/Departments is incorporated within a comprehensive database. The Gati Shakti Master Plan uses geo-mapping and real-time data in one centralized portal Dynamic Mapping of all infrastructure projects with real- time updation are

provided by way of a map developed by BISAG-N. The map is built on open-source technologies and hosted securely on cloud of Govt. of India (i.e. MEGHRAJ) . It uses satellite imagery available from ISRO and base maps from Survey of India.

The comprehensive database of ongoing & future projects of various Ministries has been integrated with 200+ GIS layers. Individual Ministry is given separate login ID to update their data on a periodic basis. Data of all the individual Ministries is integrated in one platform which is available for planning, review and monitoring. The Logistics Division, Ministry of Commerce & Industry (MOCI) provide further assistance to all the stakeholders through BISAG-N for creating and updating their required layers in the system and update their database through Application Programming Interface (APIs).

Progress So Far

A Study conducted by the Reserve Bank of India and the National Institute of Public Finance and Policy have estimated that every rupee spent by the Govt. in creating infrastructure yields GDP gains worth Rs. 2.5-3.5 accrue. Therefore, it is intended to use both "Gati" (गति) and "Shakti" (शक्ति) infrastructure development. Therefore, links with other modes of transport networks need to be addressed. The Gati Shakti (National Infrastructure Master Plan) launched on 13th October , 2021 and just after one year, the National Logistics Policy was formulated on 17th September, 2022. The Gati Shakti National Master Plan support the National Logistics Policy. The multi-trillion flagship projects such as Sagarmala, Bharatmala, and dedicated freight corridors are already working in this direction.

Example I: The Ministry of Ports, Shipping and Waterways (MoPSW) has identified nine high-impact infrastructure projects worth Rs 1,913 crore as part of the Pradhan Mantri Gati Shakti-National Master Plan . The high-impact projects is closely monitored through 2022-23.

Source: Business Standards, April 11, 2022.

Example II : The PM Gati Shakti is a digital platform which aims at promoting integrated planning and coordinated implementation of infrastructure connectivity projects. The NITI Aayog has been assigned to map different projects such as industrial corridors, freight corridors, national industrial manufacturing zones, industrial parks, logistics parks and pharma hubs, among others to be incorporated under the Gati Shakti initiative.

Example III: The Govt. of Uttar Pradesh made mandatory for all the departments to use the "PM Gati Shakti Portal" for planning of projects in the series of efforts for ease of doing business and ease of living. Further, all information of current and future projects worth above 50 crore should be on the Gati Shakti portal . Furthermore, information about land records, drainages, power transmissions, roads, sewer lines, water supply, electricity poles, traffic lights poles, bus terminals, should also be available on Gati Shakti.

Source: www.dailypioneer.com.

Example IV: Gujarat became first state to develop "State wise Gati Shakti Portal under PMGS-NMP" for multimodal connectivity. It is known as "PM Gati Shakti Gujarat Integrated Master Plan Portal".

Example V: In order to implement the Gati Shakti initiative, Indian Railways has created a separate directorate in the Railway Board with its branches at Khurda, Bilaspur, Delhi and Bengaluru divisions. Further, Indian Railways has identified 74 "Gati-Shakti Multi-Modal Cargo Terminals" across the country.

Source: PTI News, dt 27.05.2022.

Gati Skakti Gujarat Portal

The Gati Shakti Gujarat Portal focuses on the speedy execution of infrastructure projects in the state. Through the portal, the processing of applications, granting permissions and monitoring the progress of the projects are made faster. The portal has various infrastructures and their multi modal connectivity. The same is described as shown in Table 3.

Gujarat has become the first state to launch Gati Shakti Portal at State Level. The portal offer investors ease of doing business, by bringing more transparency to the governance. It also saves time, money, and logistic cost. Further, Gati Shakti Gujarat Portal will integrate more than 500 layers of data from 21 state government departments and 52 sub-departments.

Table 3 : Gati Shakti Gujarat Portal for Multimodal Connectivity

S.N.	Infrastructure	Connectivity	Remarks
i.	Pragati Paths	It is High Speed Corridors (high-ways) connecting the ends of the state.	Widening of 3710 km highways with a budget of Rs 2488 crores.
ii.	Vikas Paths	It is State roads passing through municipalities, urban areas, towns, and cities.	It is a program to modernize state roads passing through urban areas, big towns and cities
iii.	Kishan Paths	It is connecting to market places for farm products and milk	This initiative has improved the quality of life of the farmers as farm products and milk are reached to markets at the earliest.
iv.	Pravasi Paths	It is connecting to the tourist destinations.	Improved connectivity among more than 60 tourist destinations through the pravasi paths.
v.	Railways Connectivity	Railways networks in the state.	Promoting development of railway sector.
vi.	Pipeline Gas Grid Network	Connectivity in 25 districts.	Connecting major industrial centers.
vii.	Water Grid Network	To establish state wide water grid network of 75,000 km for distri-bution of water for irrigation.	Drinking water grid to supply water to cover 14,000 villages and 154 towns.
viii.	Port Network	Pvt. Sector participation in port development.	Pipavav on the coast of Gujarat is the first private sector port in India

Source: www.indiaseatradenews.com/gujarat-becomes-the-first-state-to-launch-pm-gati-shakti-gujarat-integrated-master-plan-portal.

The Gati Shakti plan will ensure not only the ease of doing business but also the ease of living for citizens. The portal is developed by Gujarat Infrastructure Development Board in association with Bhaskaracharya National Institute for Space Applications and Geo-informatics.

DISCUSSION AND CONCLUDING REMARKS

The common digital environment requires synchronization across various government levels and departments to execute infrastructure projects. The ongoing Gati-Shakti plan aims to achieve synchronous decision making process of different infrastructural projects across the country to provide seamless and efficient movement of goods, services and people. Such initiative needs to be adopted at the earliest in plan making process by the state and urban local bodies.

There are hindrances in infrastructure projects such as delay in land acquisition, impacts on agriculture production, livelihoods, micro environment, etc. Therefore, infrastructure developed by the State Governments, as per the Gati Shakti Master Plan, needs political and economical support in national and public interests.

The uploading of relevant information on "Gati Shakti digital platform" needs digitization of data/ maps and project formulations on GIS platform. The capacity buildings of such agencies which may not have significant digital footprints are required.

The Gati Shakti-National Master Plan for multi modal connectivity is a digital platform to bring 16 Ministries including Railways and Roadways

together for integrated planning and coordinated implementation of infrastructure connectivity projects. It facilitates the last mile connectivity of infrastructure. In this context, preparation of Regional Plans of various regions and Master Plans of towns/cities for development with horizon year of next 20 years on digital platform (GIS based) is a step forward for better integration and implementation of infrastructure plans and projects across the states and regions. Further, compatibility with the digital technology makes more accurate and faster way of monitoring and implementation of urban development projects incorporated in such plans.

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ICT ENABLED PLANNING AND INFRASTRUCTURE SERVICES

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Abstract

The breakthrough in technology with the application of microchips, micro-computers, microwaves, nanotechnology, block chain, GIS, GPS, cyber-space, 5G/6G wi-fi and e-topia are changing the familiar borders like inside-outside, private-public, here-there, city-country and yesterday-tomorrow. The world of infrastructure services is characterized by intelligent and smart services, dynamic networks and floating nodes. The paper dwells on the range of ICT enabled planning and infrastructure services, in this changing era of fourth and fifth industrial revolution, which can transform cities and buildings towards low carbon, sustainable and circular development.

INTRODUCTION

The collapse of the Morbi suspension bridge in Gujarat on October 30, 2022, killing 135 people, has shocked everyone. A 206-meter-long old bridge in Begu Sarai (Bihar) on Burhi Gandhak river, after its repair and renovation collapsed on December 18, 2022, even before it was opened up for traffic. The recent floods in Bengaluru and Chennai indicate the lack of information, deficient planning and infrastructure services. After 75 years of Independence about half of the population still lives in unplanned areas and slums. The 2021 Niti Ayog report states that 65% of 7938 cities and towns in India do not have a Master Plan. As a result, our cities fail to address the impending issues of pollution, water and energy shortages, joblessness, climate change, transportation, and utilities.

INFORMATICS FOR PLANNING AND INFRASTRUCTURE SERVICES

The ICT can be a game changer in this transition towards a green and clean economy, smart, resilient, and low carbon infrastructure services, transport and community. This needs specialised inputs in urban planning by domain experts in GIS, GPS, EIA, SDI, big data analytics, ERP solutions, digital dashboard, blockchain, AI, ML DL, etc.Some key areas concerning sustainable cities, smart and speedy planning and infrastructure development are given below in Table 1.

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DIGITAL PLANNING

The breakthrough in digital technology and informatics has multiplied space, energy and time. It is time that circular forms of economy, planning, energy, services, construction and recycling evolved, which are sustainable, smart and resilient (Fig. 1). The urban processes need to be compatible to circular economy by adoption of new technologies, such as digital blockchain, combinatorial and discrete optimisation, algorithms, complex theory, artificial intelligence, big data, and the ubiquitous cloud.These are characterized by online exchange of information, interactions, dynamic networks and floating nodes. The project can be planned integrating the physical, economic, social, ecological and health aspects by a sustainable Project Compass. This requires new rules of artificial intelligence, machine learning and deep learning (Fig. 2).

Integration of land use, utilities, transport and building on a common network helps optimize space efficiency, use and configurations, eliminating unused or underperforming space. Digital planning can facilitate public participation at local level integrating the community, ecology, services, transport, built environment and heritage.

By developing sector–focused, cluster–based intelligent strategies, city can set in motion innovation mechanisms and enhance substantially. The ICT can help in the integration of citizen participation, governance and online consultation over plans and programmes of local development.

Table 1: Informatics for Planning and Infrastructure Services

	ICT Enabled Fields	Some Key Areas
1.	Digital Informatics for Planning and Green Buildings	• CAD and CAM enabled Planning, Design and Construction • Integrated Digital Planning, Conservation of Land, Natural Resources, Heritage and Environment • Digital Land Information System, Digital mapping, SDI, Geo-portal, GIS based property records, plans and transactions • GIS, GPS, Remote Sensing, Total Station/Drone/ Satellite Surveys, Gyroscope/Accelerometer based High Resolution Imagery, Photogrammetry, Alphanumeric Pin, High-definition Dynamic Digital Mapping, Laser Scanning and Penetrating Surveys for Infrastructure, Foundations and Structures • Big Data Analytics, ERP Solutions, Artificial Intelligence, Machine Learning and Deep Learning • EIA, Heritage/Transport Impact Analysis, Experience Simulation, Concept Generating Matrix, Morphological synthesis, LiFE Platform, Digital Ledger and Dashboard • Apps for Public Participation, such as wEconserve by SPA New Delhi • Climate Resilience Environmental Management, Urban Heat Mitigation, Sky View Factor • Smart/Green Buildings, Net Zero Energy and Water, Parametric Design, Morphotectonic Strategies, Animation, Simulation, Algorithm and Equations, 3-D Modelling and Printing, Augmented and Virtual Reality, Computational Design, Design Thinking, User Experience and Interface. • Digital Fabrication, Morphogenic Geometry, Biomimicry, Adaptive Systems, NURBS Curves and Surfaces, Spline Topology, Voronoi, Genetic Computation, Fuzzy Logic, Robotics, stereolithography, etc. • Building Information Modelling • Online digitise building plan approval and clearances (the competent approving officer to give on the spot decision as in the Passport Officer
2.	Land Management	• Digital Blockchain, Land Administration Digital Model (LADM), Land Pooling • Accommodation Reservation, Transferable Development Rights, Optimising FAR and Densities

3.	Energy	• Common Digital Platform • Energy networks, smart grids, smart meters, smart buildings • Renewable energy, Trigeneration • Electric vehicles, Green Hydrogen, Hybrid CNG • Power quality monitoring • Energy conservation, storage, and efficiency • Bionic Controls, Passive Evaporative Draught Cooling, Earth Air Tunnel, Daylight design • Intelligent management/maintenance, MIS
4.	Public Utilities	• Realtime Digital Platform for Utilities, Pollution, Quality and Quantity standards • SCADA (Supervisory Control and Data Acquisition) • ERP Solutions • Intelligent water and sewerage networks with minimum losses and leakages, Micro-Irrigation, Plug the Non-Revenue Water (NRW) losses, Intelligent flood control and sustainable urban drainage • Intelligent metering, billing and payment • Solid and Liquid Waste Recycling • Non-invasive techniques and advanced analytics for managing the water supplies and pressure in the network, which reduce energy consumption
5.	Smart mobility	• Transit Oriented Development, Origin-Destination Adaptation and Traffic Optimisation modelling, • Roadside Sensors for Traffic Monitoring and Real time congestion information • Simulation modeling and analysis • Smart cards, driverless vehicles • EV, Green Hydrogen, Ethanol blended CNG Network of Charging Stations • Greening and Revamping of Streets as pedestrian and cycle friendly Boulevards • Intelligent Multi-Modal/Public Transit, NMTs • Replacing On-Street Parking by Multi-Level Parking • Smart signals, traffic controls, variable signage, mobile enabled real time maps/routes, way finding, etc. • ICT enabled traffic control, vehicle safety, communication, Dynamic Regional Network Modelling, Multi-modal Integration, Fleet Optimisation Modelling • Safety and security, accident monitoring, forensic analysis • Infrastructure integration, Smart City Pole with Air Pollution Sensors • Digital Taxi/Car/Bus/Auto Pools • Maintenance, MIS and management

6.	Intelligent Community Frameworks	• Digital, Intelligent Community Planning • Networked Education, Health, Recreation and Other Facilities, • Urban Farming • Digital Data on Residential Types, WFH, Hostels, Night Shelter, Social Rental Housing, etc.
7.	Disaster Management	• Public Security System and Safety • Intelligent Public Security System and Safety • Early Warning System, Emergency Aid, Rescue, Relief, Repair, Restoration and Reconstruction, Medical Aid, Life Support, Digital Information with regard to Fire and Structural Safety of Buildings • Intelligent and Integrated Digital Control and Command Center , CCTV Network
8.	Telecom Networks	• Broadband development, home automation, Internet access, • ICT support, capacity building and training • Consolidated billing • Business incubation center, Climate Centre, Electronic trade office, City Administration, Technology and Innovation Centre • Geo-portal, mobile based supervision and control
9.	e-Governance and Urban Management	• E-Governance, engagement with India Urban Data Exchange, National Urban Learning Platform, Smart Code, National Urban Development Mission • Planners, architects and engineers have a Shorter Shelf Life unless they Refresh and Rebuild capacities • A Shift from Long Range Planning to Strategic Planning • Interdisciplinary/Transdisciplinary teams and Collective Intelligence

Global positioning systems are being increasingly used for construction, laying of services by satellite-guided tools and GPS devices. By 'on-site' virtual system, pipe work installed in a building can be inspected by a worker. Before installation, a contractor digitally tags every pipe and electrical system; once installed the engineer can view an augmented version of reality through 3D glasses that recognizes the tags and displays exactly where a misplaced pipe should be, relaying data back to a central control unit via a handheld computer.The 3 D cameras recognise the objects and material, and whether they are being used at the right place and with accuracy. The smart fingers can measure the distance between the two points.

GREEN AND RESILIENT BUILDINGS

A low carbon and green building aim to be resilient, sustainable and net zero. It is a synergy between various components such as energy, water, materials, waste, land, and indoor environment. The lifecycle approach of circular construction manifests the stages of design, construction, products, materials, operation and maintenance, and renovation. As the buildings are responsible for approximately 40% of the total energy use, incorporating renewable energy storage into them will increase their resilience. Bionic controls and energy efficient Power-Over-Ethernet (POE) lighting system enables lighting from a solar grid.

With passive design and low embodied materials, the buildings can be more comfortable. Such materials include carbon-negative cements, low carbon steel, fibre, gypsum, basalt, fibre composite bars, bamboo, etc. Computer-Aided Manufacturing (CAM), Computer Integrated Manufacturing (CIM),prefabricated and pre-engineering systems contribute to lowering the carbon emissions, dust, time and costs in construction.

Building Information Modelling (BIM) can simulate the entire construction sequence beforehand addressing sustainability issues and reducing carbon emissions. The simulation of construction process enables better control of time, machine, expenditure and the manpower, and could reduce carbon emissions, costs and time.

After the corona pandemic, the trend is shifting towards healthy spaces and work from home (WFH). This emphasises upon open office, biophilic design with natural light, ventilation, greenery, atrium and courtyardswhich help in better indoor air quality. The building must conform to accessibility standards for people with disabilities.

GREEN ENERGY

Low carbon energy can be derived from renewable sources, such as biofuels, wind, tidal and solar power. The concept of energy efficiency, renewable energy and Zero-fossil Energy Development (ZED) can reduce energy demand and consequent pollution. Smart Micro-Grids, Distributed Energy Systems (DES), Micro-Districts and Anchor Microgrids should be linked with renewable energy network and energy efficiency. A series of low carbon zones across the city with co-located tri-generation energy systems (combining power, cooling and heating), can lead to 'green energy. Intelligent, smart poles for streets and parks can save energy, while also providing information on air quality, maps, wireless charging, congestion, CCTV, etc.

The energy guzzling air-conditioning can be avoided by innovative methods like Net Zero Energy Design, variable refrigerant volume (VRV) system, earth air tunnel (EAT), thermal storage and Passive Evaporative Draught Cooling (PEDC) systems. Lower ambient lighting, bionic controls and integration of natural light with high performance glazing combined with light sensors can save energy use in a building. Synchronized lighting control systems can be designed to match building loads and schedules, which are segmented into multiple zones to allow intelligent controllability. The Energy Conservation Building Code (2017) provides guidance for energy efficient building design with green roof, light coloured finishes and insulation. Parabolic curved mirrors can harvest solar heat for cooking and water heating.

WATER CONSERVATION AND MANAGEMENT

With increasing river pollution and drying of water bodies, several cities in India have become water stressed. Only 18% of the renewable water resource is being recycled, and only 10% of the annual rainfall is being harvested in India. To

overcome these problems, water sources need to be planned and managed as circular systems. The water bodies and the rivers need to be protected by sanitation/sewerage interception, and by recycling and treatment of wastewater. Zero run-off drainage needs the provision of swales, retention ponds, etc. Besides the conservation of rivers and water bodies, water efficient taps/fittings, dual plumbing and recycling of wastewater by DEWATS.Adoption of new technologies, such as Blockchain and SCADA systems, can help in a more efficient water supply.

Satellite controlled park and lawn micro-irrigation system cuts water consumption and pumping power. Wastewater recycling, with dual piping would reduce water demand. Collecting rainwater and growing food locally in urban areas can respond to the challenges of urban-rural divide, biodiversity, social equity, waste minimization, and energy.

DECENTRALISED AND INTELLIGENT UTILITIES

Almost 40% of urban population in India is not covered by sewerage, sanitation, drainage and solid waste disposal. Various alternative technologies, based on the use of IT, simulation, blockchain and automation can make the utilities smart and intelligent. Instead of land filling for solid waste disposal, decentralized systems based on 5R strategy of reduce, refuse, reuse, recovery and recycling should be explored. Provide separate bins for trash, recyclables and compost. Biotechnology, enzyme based STP, bio-remedial treatment, vessel system, sludge gas/energy recovery, vermi-culture, fossilization, and compositing options can be adopted for solid and liquid waste management. Underground pneumatic conveying systems can be adopted, which are more hygienic, economical and avoid movement of trucks for transportation of waste.

Smart Mobility: Intelligent transport planning can provide seamless, safer, efficient and effective management of traffic and transport. Similar results are also visible by use of IT in the planning and management of transport infrastructure and services like taxis, autos, goods transport, signaling system, signage, transport simulation, etc.

Intelligent Community Frameworks: Community facilities such as health, education, recreational and other neighborhood services need to be planned to the highest standards of leadership in energy and environmental design (LEEDS) that saves energy, materials and emissions. A smart neighborhood strives to achieve infrastructure efficiency, conservation of water, energy and natural resources.

e-Governance: Hon'ble Prime Minister Shri Narendra Modi in 2015 had said that"To me, e-Governance is nothing but easy, economic, and effective governance.e-Governance is a key component of good governance, which is key to sustainable development".In any city there are more than 100 citizen services that require engagement with civic authorities for enquiries, registration, form submission, payments, grievances, etc. The availability of e-gateway for citizen service delivery has attracted much attention in municipal governance and is bringing out a silent revolution in many city corporations, breaking the barriers of distance, class and gender. GIS enables citizens to take photos on mobile and send an SMS to the administration, that would metamorphose e-governance.The dashboard will capture and address the complaint and escalate the matter to higher authorities, if unaddressed. The e-services can make the governance more transparent, time-bound and integrated with related modules like property transactions/taxes, building plan approvals, trade and market license, water billing, etc.

CONCLUSION

Hon'ble Prime Minister Shri Narendra Modi said 'I believe that IT+IT=IT. That means Indian talent and information technology is equivalent to India tomorrow. It is my firm belief that our talent will build the future of India with the help of IT'.'India is on the path of massive infrastructure development. This is the lifeline and the engine of productivity and wealth, leading to sustainability and improvements in people's lives. In this context, it is necessary that the infrastructure services are networked, automated and connected with high quality engineering, planning and construction. This involves creating common digital platforms for infrastructure services, including their maintenance and management. Big

Data Analytics, ERP Systems, GIS, GPS, BIM, CAM, CIM, Blockchain, SCADA, LADM, Simulation, Robotics, Solar Mapping, Stereolithography, Nanotechnology, etc. are de rigueur of sustainable ICT enabled planning and infrastructure services.

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Fig. 1: A Circular Economy is Restorative or Regenerative aimed atMinimising Wastes and Making the Most of Resources

Source: Khan, Khalil Uttah (2022) Wastewater Reuse, Linear Economy to Circular Economy, Shashwat, TERI, New Delhi

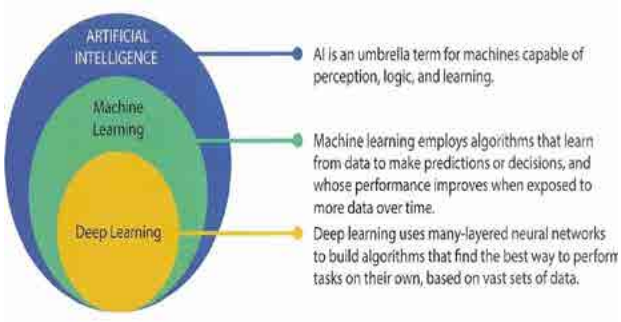

Fig. 2: Components of Artificial Intelligence

Source: Verma, Seema, Towards Data Science, Shshwat (2022), TERI, New Delhi

DIGITAL TECHNOLOGIES IN FACILITIES MANAGEMENT AND A FRAME WORK FOR COMMON DATA ENVIRONMENT

DR. K. SRINIVAS*, DR. K. R. RAMANA AND MURALIDHAR*****

Abstract

Every country irrespective of the status of its economy constantly strives to develop their abilities by way of innovation, learning by execution and by investing in research and development in critical areas so as to keep abreast of the latest developments that is sweeping the globe. In this context, India has set itself an ambitious target of doubling its economy in five years to Rs 5 lakh crore by 2025. It is also making continuous and concerted efforts to digitalize the operations across the various industries so that the wastage is minimized and productivity is enhanced. Hence, it has become imperative for the organizations that are involved in Construction and Infrastructure Facility services to switching over their operations from physical form to digital platform for enhancing their practices and making their operations agile. The new challenges for Facility Management calls upon delivering the value with the given constraints of investment, productivity, sustainability, workplace design, accessibility, technology and regulatory compliances. This paper covers the opportunities underlying facility management practices, benefits of going for digital platform, dimensions of digital facility management and future of digital facilities management practices. The paper also highlights a frame work for building a successful Common Data Environment for the benefit of Facility Manager as well as Energy Manager.

INTRODUCTION

Facility Management (FM) is concerned with management of any type of facility be it an infrastructure or a building and basically involves integrating people, place, process and technology. The primary objective is to manage the facilities and services in an effective manner leaving the core business activity to the business owners. Traditionally FM was done in house by the organization itself. However with increasing focus on core business by the organizations, the outsourcing of FM commenced.

There has been an improvement in FM technologies and practices and it is on the cusp of a major transformation. Advancements in software and integration of building data with enterprise systems simplifies the workload for Facility Managers. This is backed by increasing innovation with powerful analytical and reporting capabilities. These are expected to continue to take a quantum jump in near future so that Facility Managers can take decisions based on real time data and become knowledgeable advisors for their organizations.

The outburst of digital evolution has introduced a new paradigm in FM. In this, the entire operating cycle of FM is executed through digital technologies.

The first wave of digital FM was about generating, storing and sharing digital versions of traditional documents and drawings. It was putting facility data into in-house databases.

The second wave of digital FM is about intelligence of shared data, re-engineering the process and involving extended cross organizational team.

The use of digital technologies has also resulted in lesser dependence on labor and the progress achieved can be accessed from any part of the globe with the help of getting real time data from the site which can be of help in completing the project with minimum disruptions.

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TECHNOLOGIES INFLUENCING FACILITY MANAGEMENT

Technology is one key trend influencing Facility Management of today. Technology and changing attitudes to the workplace are driving a transformation of corporate real estate and with it, the traditional image of the real estate professional.

Gone are the days when the real estate function was seen as an overhead and its professionals solely as engineers. FM is coming of age and the next generation of real estate professionals will more closely resemble business managers and leaders who combine empathy, strategic thinking, commercial expertise and an eye for innovation and continuous improvement. This will more accurately reflect the role of the function as an enabler of change and agility as well as a key driver of performance.

Data Driven Decision-Making

Smart workplaces equal smart insights. The benefits of internet-enabled building management systems are compelling. A smart workplace has the ability to put all of our systems on a common reporting platform which will generate easily accessible information and identify faults, performance issues and cause-and-effect scenarios. It also gives us the ability to manage our space now and forecast what we need in the future. By 2025 it is predicted that data analytics will be critical for addressing issues such as energy savings, reduction of total life cycle costs, business efficiency and sustainability.

Better data quality and accuracy is the key to achieving strategic real estate goals. The key drivers of performance are property and people and the link between them. In most cases the technology tools exist to allow them to do this and that there is no shortage of information per se, but harnessing it to address strategic challenges is still a major task.

If organizations invest in technology, it can give them a better window into their world, enabling them to make more informed decisions. Strategic insights data doesn't just make a difference when it comes to individual assets. The same principle can be applied to all aspects of the portfolio and drive significant value.

SMART TECHNOLOGY AND ARTIFICIAL INTELLIGENCE

Imagine arriving at a building for a meeting where the electronic security system automatically recognizes us, scans our iris or fingerprint and allowing us go through the barriers. On taking the lift, the lift which already knows which floor you need and when you emerge and our phone shows us the most direct route to meeting room. On reaching at the meeting venue, the temperature and lighting adjusts to take into account the number of occupants in the room and the telecom system automatically dials in the conference call.

The technology which exists to make this happen – the 'Internet of Things' (IoT) as it's known, relates to the ability to connect devices over the Internet and allow them to talk to us, to applications, and to each other. Only a few companies have truly brought the concept of the smart building to life yet. But it's predicted that intelligent buildings will be commonplace by 2025.

Every asset or device within the building – such as lights, sensors, windows, HVAC units, doors and CCTV will have a unique identity and all fully integrated into a network.

Improving User Experience

Creating smart buildings through energy efficiency, sustainability and the ability to support a mobile workforce are big drivers for clients today. A lot of it has to do with attracting and retaining the best staff, making life as comfortable and as easy as possible for people. Clients see smart buildings as a means of enhancing the 'customer experience' for employees. They offer corporate real estate professionals the kind of detailed data-driven insights into the customer experience they're actively seeking.

Today workspace needs are changing for every sort of business and works require a blended approach to work with geographic and lifestyle benefit of choosing where and how to work.

They also want creative and productive environments close to home and freelancing and multiployment are increasingly becoming realistic and attractive options.

Wellness

The next key trend is wellness. Wellness is one area that's close to the hearts of millennia's who have a particularly high commitment to health and wellbeing. As Goldman Sachs reports, millennia's define 'healthy' as more than just 'not sick'- it's a daily commitment to eating well and exercising.

Wellness is emerging as the key influential trend as social, demographic and technological changes drive a more proactive approach to managing health and well being.

In real estate sector companies, across the region are investing in programes to enhance the well being of their employees and it's not hard to see why these programmes are growing in popularity. As, apart from supporting the wellness of employees, they bring benefits for business.

FM professionals that introduce health and wellness services are helping to attract and keep talent and reduce the cost of absenteeism. Research suggests that there is a direct relationship between wellness measures and the bottom line as they can improve employee productivity by an average of 10 per cent. Wellness in the workplace is one response and is seen as a key way of attracting and keeping key talent. In these days of disruption and disintermediation there's a constant pressure on organizations to innovate and here too, the workplace has an important role to play, supporting collaboration and boosting creativity.

DIGITAL FACILITIES MANAGEMENT

Facilities management is changing rapidly. What was once a role reserved for building services management has now developed into a multi-channel position which encompasses aspects of IT and Human Relations. As our expectations of building capabilities grow, so do our expectations of facilities managers. FM today considers the comfort and individualization of workplace for every Built Asset be it a building, infrastructure like operation and maintenance of highways, maintenance of utility and O&M plants, maintenance of power plant, ports and air terminals etc.

With the adoption of Building Information Modeling, real estate owners have accurate data rich 3D models of operational buildings. These models are developing into a digital twin of the building, a dynamic virtual representation of a physical asset using real-time data to optimize property performance.

- The digital twin enables facilities management to digitally test options before implementation.
- Digital FM provides the building manager with easy access to building information to manage operations and maintenance of buildings throughout their operational lifecycles.
- Facility managers are finding value in several areas of building operations that benefit from enhanced data.
- Businesses want access to great workspaces for their people on-demand without the hassle of managing the property.
- They also want to avoid fixed leasing arrangements liberating them to allow for rapid expansion or contraction.
- Businesses need a portfolio of workspace options that is both global and local which provides blend of options that maximizes business agility, employee satisfaction and cost efficiency.
- Building up as a leading and an information technology platform, will enable the companies to integrate with customer organizations and their people.

Optimized Maintenance

The key challenge in developing a maintenance program is entering the product and asset information required for preventive maintenance. Asset data included in the BIM model during design and construction removes the need for lengthy implementation of new software.

Reduced Energy Costs

Access to digital models helps facilitate the analysis of energy alternatives to help facility managers reduce environmental impacts and operating costs.

A Golden Thread of Information

- Increasing legislation and compliance means access to accurate records for building managers and owners.

- Throughout their lifetime buildings are continually evolving and changing. This information must be kept up to date.
- A digital model allows all changes and activity to be easily maintained, monitored and analyzed.

Improved Space Management

By understanding the details of how space is used, facility professionals can reduce vacancy and ultimately achieve major reductions in real estate expenses. Accurate and accessible room and area information models are the foundation for good space management.

Efficient Refit

A 3D model provides the building manager with an understanding of the space and its systems. Better information about existing conditions reduces the cost and complexity of remodeling and fit out. By providing more accurate and dependable information to contractors, change orders resulting from unknown as-built conditions can be greatly reduced.

Enhanced Lifecycle Information

Life expectancy and replacement information can be added to the model through design and construction helping an owner to understand the benefits of investing in materials and systems which may have a higher capital cost, which in-turn will reduce the ongoing operational cost. By capturing this data there is a continuous improvement loop through construction and operation.

Twin view takes the handover model with all commissioning, operation and maintenance information included and hosts it on the cloud meaning it can be accessed and maintained by anyone from anywhere on a mobile device.

Data from IOT devices and FM software helps facility managers understand more about how their workplace functions and what decisions need to be taken to showcase their best.They are taking the data and breaking it down to recognize the trends like turnaround time, inventory management as consumption patterns. Data is also used to manage labor cost on specific tasks and increase efficiency through automation. From client's perspective, data driven decision making will help in optimizing available office space and changing the way work environment is managed. The result is savings on overhead costs and smarter space utilisation. This is furnished in figure below.

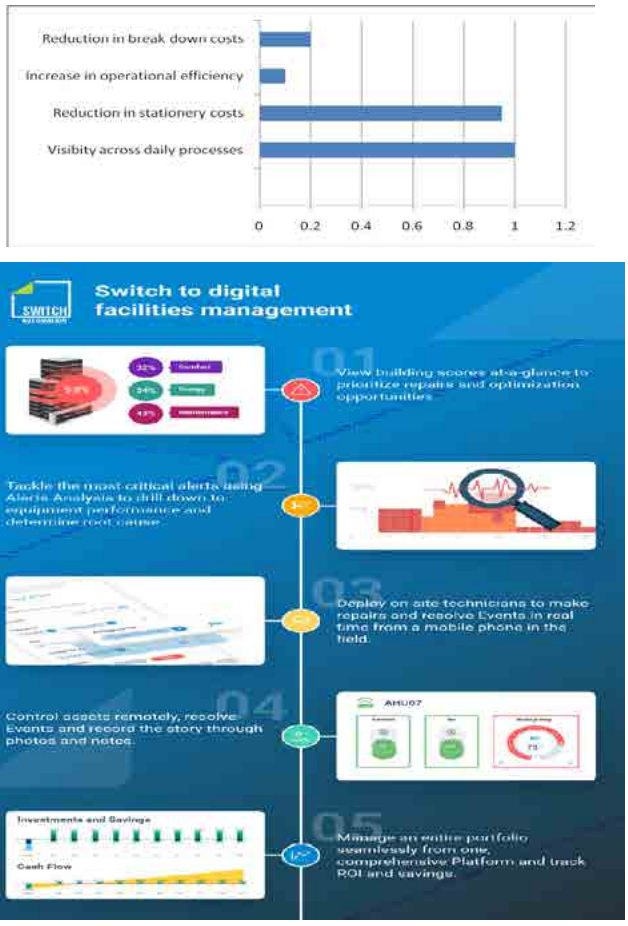

Fig 1: Results in Savings as (%) Across Various Activities

Source:https://info.switchautomation.com/what-is-digital-facilities-management

FACILITIES MANAGEMENT- VALUE ADDITION

The value addition due to digitalizing FM Practices are:

- Flexible leases with minimum lead times and no setup costs
- Access to virtual office services that gives freedom to work from anywhere
- Chance to brainstorm with and learn more from established businesses

- Cost effective digitalized fully equipped spaces that helps in increasing the credibility of an organization among clients and employees
- Access to latest technologies which helps the company to differentiate from its competitors

DIMENSIONS OF DIGITAL FACILITIES MANAGEMENT

The following are the dimensions of Digital Facilities Management:

- For managing, maintenance and repair
- Improving of energy management
- Data gathering through computerized process
- Automated workflows which helps in rectifying the fault, if any
- Getting real time building usage and performance data
- Facility managers can advise tenants on right facility services depending on their organization culture by benchmarking the date with similar organizations
- From reserving conference rooms to adjusting lighting and temperature preferences, FM provides employees with new levels of space personalization and efficiency
- Data derived from these preferences can be used to enhance and optimize the space
- Electronic controls for managing heating, cooling and lighting
- Machine to Machine communication and sensors
- Advanced energy management systems which can observe complex usage patterns and the energy usage can be tailored for particular occupants
- On demand temperature and lighting apps that office workers can operate
- Remote monitoring and control functions for a multiple building system can be monitored from central command centre that can help fault detection and diagnostics and attending to the faults from the command centre and for issuing of alerts, if any emergency situation arises.
- Managers can oversee vendor relationships across multiple properties simultaneously to make sure budgets are not being exceeded.

BENEFITS OF DIGITAL FACILITIES MANAGEMENT

There are a host of benefits obtained from digitizing Facilities Management Practices.

- Efficient collaboration between participants in FM function
- Fully automated monitoring
- Efficient space utilization
- Improved project planning
- Streamlined and improved processes
- Improved disaster planning capabilities
- Data standardization across organizations
- Integration with existing systems and process

A FRAME WORK FOR BUILDING A SUCCESSFUL COMMON DATA ENVIRONMENT FOR FACILITY MANAGERS

Common Data Environment(CDE) can be defined as an information architecture and application, generally available in the cloud, accessible from any device be it Personal Computer, tablet or smart phone from which it is possible to manage projects in a consistent structured yet adaptive way promoting collaboration between users. The CDE allows all users involved in the Facilities Management process to share in a single database in real-time. Information is always available in real time and up to date, it facilitates collaboration between team members by avoiding duplication of information and minimizing the possible occurrence of errors at every stage of work- cycle.

Building a successful Common Data Environment involves:

- **Choosing the Right Team:** choose team members with the right Management and Technical skills necessary to work collaboratively to achieve desired project outcomes. A motivated competent team is key to success.
- **Define Roles and Responsibilities:** Roles, responsibilities, deliverables and schedules must

be clearly defined, ensuring that each team members is assigned proper access to Common Data Environment.

- **Define Approved Workflow:** Clearly decide who can do what, for example who can access to certain type of information or documents. Define with which rules documents and the teams activities should be approved
- **Common Language and Data Availability:** Define a common glossary of terms, definition and data architectures, including the formats and use of non – proprietary open formats when ever possible.
- **Give Preference to Securing Data:** The CDE must meet data safety and service level requirements, including encryption and data recovery. Include multiple levels of access based upon user and information types.
- **Building Information Management:** A Common Data Environment in combination with life-cycle centric Building Information Management enables significant cost savings as well as on-time, on-budget project delivery and improved levels of satisfaction for all participants and stake holders.

The Facility Manager as well as the Energy Manager and related peers can depend upon a Common Data Environment to assure available access to Historical, Current and Planned Operations and Maintenance Management activities, costs and impacts. Within the CDE, a wide range of standardized information can be stored and immediately accessed. Building locations, horizontal infrastructure movable assets (equipment and furnitures) major building systems, major equipment and people (both internal and external)

CONCLUSION

Facility Management being a Post Construction Project activity for Managing any built asset be it a Infrastructure, Utility Plants, Research and Development Centre or Laboratory, Manufacturing or Ware House facility etc. where the time duration and resource requirements are considerable during the life cycle of an asset. There is a need to see how efficiently and effectively the activities are integrated by the application of Digital Technology & transcending to Common Data Environment (CDE).

Digital transformation in facility management has kept evolving by automating manual tasks connected with business processes. It also introduces a range of data systems. In this way, people processes, and technology create a new environment with improved service quality, productivity and performance. Facility management software takes on the role of a backbone of technological aspects. The use of innovative digital technologies and tools for conducting management operations has significantly improved the preparation and execution of a project involving facilities and has resulted in efficient collection of information required for efficient deployment of the assets by keeping the asset fit with least outages

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DIGITAL PROJECT MANAGEMENTT

B.S.MUKUND*

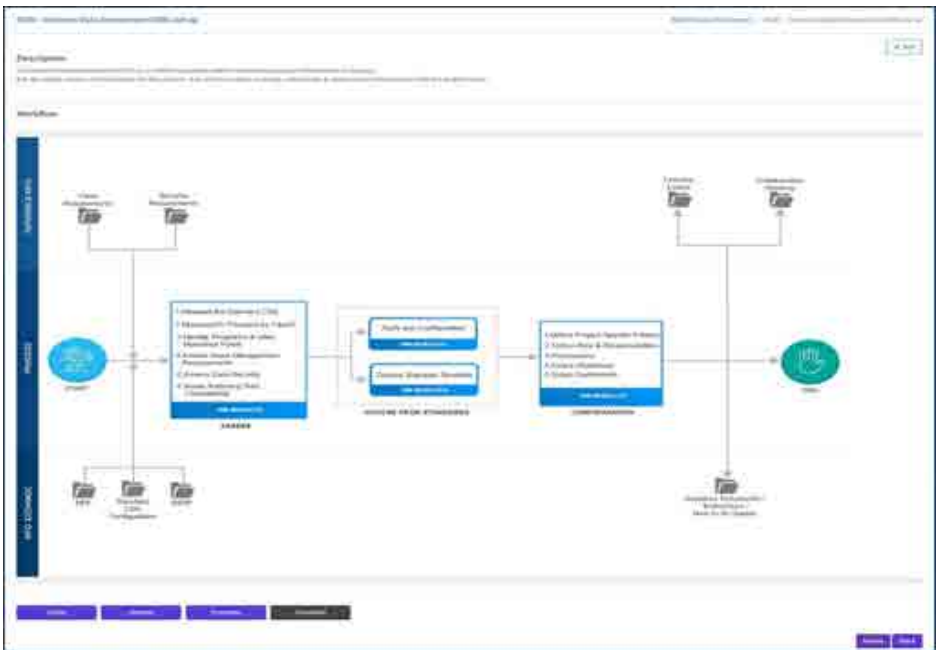
DIGITAL ENGINEERING-BIM IN CONSTRUCTION

Building Information Modelling (BIM) is a dynamic process of creating information-rich models for the entire lifecycle of a construction project. As a project passes through different phases, the level of development in a BIM model also increases to different levels namely LOD 100, 200, 300, and beyond.

- L&T 4D & 5D BIM through which we can deliver key business outcomes by connecting various parts of an organization's data together, mining it for insights and then using it for informed decisions.
- L&T BIM Process Framework to establish consistency to the way information is produced and shared to bring about the integration, offering repeatability and scalability.
- L&T Central BIM Component Library helps in setting up structured data to aid the integration.
- L&T BIM Academy imparting the right BIM competency development to leverage the benefits of BIM across the project lifecycle.
- Project BIM Initiation and Implementation service helps projects to get set up on BIM on the right note and implement BIM through its life cycle.

COMMON DATA ENVIRONMENT (CDE)

A common data environment (CDE) is a digital information platform that centralizes project data storage and access. A CDE is an inclusive repository of data generated by a project team through the design, construction, and operation phases. Multi-disciplinary project stakeholders can access the CDE anytime and anywhere using a computer, mobile phone, tablet, or machines in the field.



**Head – Building Information Modelling (BIM)*
L&T Construction

CDEs are used on many construction projects, including horizontal construction—heavy civil and infrastructure projects—and vertical construction—building projects. Common data environments are especially useful for large-scale construction projects that involve a complex web of stakeholders and rely on the exchange of large volumes of data. A CDE facilitates this exchange by providing everyone from designers to contractors to owner's easy access to real-time project data.

CDE access is based on Role & Responsibility in the project based on ISO19650 and within this environment we at L&T construction are doing the following:

- Design Collaboration
- Data Management
- Markups
- RFI (Issues)
- Approval system
- Transmittal
- Revision management
- Field BIM etc

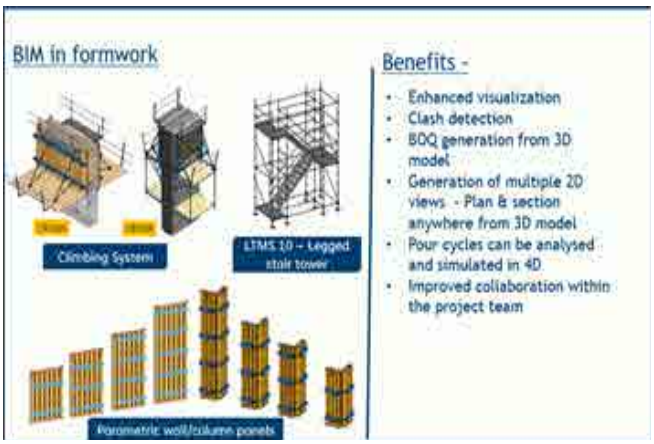
BIM Academy:

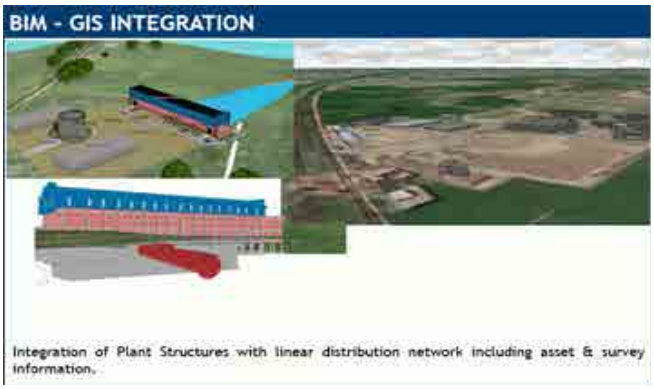
Knowledge is power, and the more our employees know, the more our business can grow. By providing technical skills training for our employees, we are instilling self-confidence that the employees have the knowledge and competence to perform their daily tasks to the best of their ability.

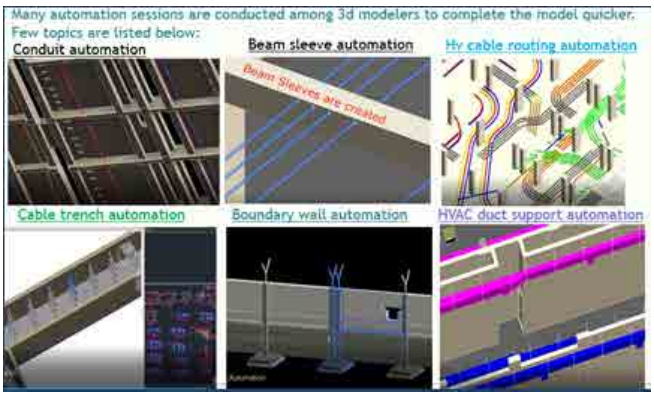
Technical training enables employees to master the technical aspects of their job. L&T Construction's BIM Academy is designed with technical training programs for different software applications and processes to increase employee efficiency and productivity, help team members learn new ways of doing old tasks, and build core technical skills relevant to their role.

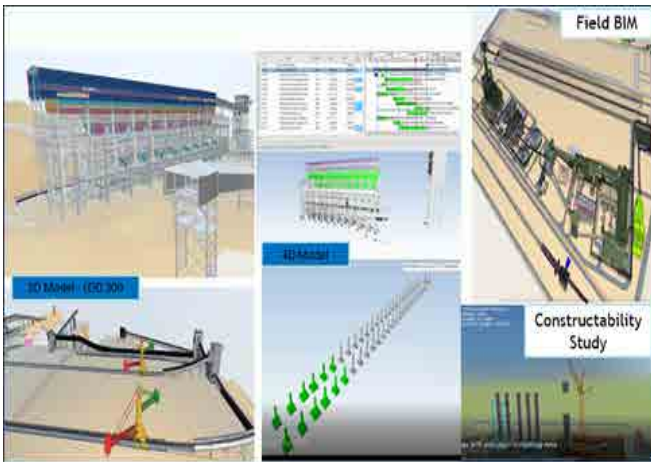
A key distinguishing factor between BIM Academy's technical training and other forms of training is that most technical training aspects are job-specific and cannot be performed without the appropriate technical skills.

Field BIM in L&T Construction:









Conclusion:

As CDE is an inclusive repository of data generated through the entire life cycle of the project I call it as "Single Source of Truth". CDE helps the document controller to keep on top of the information, helps the Project Manager to keep work on track, assist site managers with daily tasks & saves on-site staff time.

- Constant interconnection between collaborators and sharing of all data in a single environment.
- Access to information only with the necessary authorisations i.e. Role & Responsibility based access to data.
- Files updated in real time.
- Actions tracking and evidence of the historical succession of events.
- Easy access to different data formats.
- Easier comparison between different models to identify interferences.
- Easier revision control and comparison.
- Use of the tool from anywhere with any type of device.
- Automatised dashboard generation.

BUILDING INFORMATION MANAGEMENT AND COMMON DATA ENVIRONMENT

Dr. Amarnath CB*

Abstract

Indian construction and infrastructure sector is the third largest in the world by 2025. And, seventy percent of infrastructure for 2030 is yet to be build. The information lifecycle from design, to procurement, fabrication, transport, installation, commissioning and finally, handover, creates a vast amount of information. It is expected that 5-7 times productivity boost expected by using prefabrication, modular construction, augmented reality and virtualization, cloud and real-time collaboration, 3D scanning and photogrammetry, Building Information Modelling (BIM) and other documentation technologies like Common Data Environment (CDE). One of the greatest challenges faced by our construction and infrastructure sector organizations is information management. Author is discussing the benefits of a CDE-Common Data Environment utilisation information management.

INTRODUCTION

A CDE is a central repository where construction project information is stored. It is the single source of information for the project. CDE is used to collect, manage, collaborate, and share project information with the project stakeholders throughout the lifecycle. The key benefit of using aCDE is that all project stakeholders have access to the same secure, cloud-based information, allowing them to collaborate on BIM models, drawings and documents as well as digitising internal governance processes and tracking cost and programme. Not only do they streamline projects, but CDEs bring efficiencies, reduce risk and create real-time data-driven insights producing a repository where all stakeholders have a vital single source of the truth. They can connect the boardroom, the office and the field across the multiple organisations working together through the cloud.It is utmost important to make sure that the data centres are setup by the tech vendors within in India for the data security concerns. CDE can be further integrated with applications and functions to browse the models, clash detection, GIS integration, Scan to BIM activity, IOT Integration, time and cost planning, virtual and augmented reality integration, block chain integration for claims and dispute resolution, virtual meetings, design, construction and asset management activities.

PROJECTS DELIVERED WITH BIM AND CDE PLATFORMS

India's building and infrastructure sector projects are getting delivered using BIM, CDE and other related digital technologies. Building sector projects delivered with digital technologies include airports, public spaces, healthcare, residential, factories and plants, IT data canters and commercial spaces. And, Infrastructure projects delivered with digital technologies include metros & high speed rail, nuclear, hydel, bridges, power, renewable energy, dams, urban, rural & industrial water & sewage systems including STPs, and smart water infrastructure.

OPEN BIM & CDE PLATFORMS

Making sure Open BIM and CDE platforms are implemented in projects will support a transparent, open workflow and allows project members to participate regardless of the software tools they use.The adoption of digital technologies for Indian construction will offer several benefits in terms of

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risk reduction and increased efficiency. It will also enable a smooth transition to the operations and maintenance stage and better monitoring of project progress in the design and construction stage, thereby ensuring that the project is completed within the scheduled time and the stipulated budget.

INFORMATION MANAGEMENT

The information lifecycle in projects from design, to procurement, fabrication, transport, installation, commissioning and finally, handover, creates a vast amount of information. A key change can be initiated by implementing a standardized way of information flow among the stakeholders and allowing information to flow with minimum resistance. Information management is the biggest benefit of a CDE utilisation.A CDE is a central repository where construction project information is stored. It is a single source of information that can be used to collect, manage, and disseminate information – graphical models and non-graphical data for the whole project team. Right implementation of a CDE reduces the friction of information flow and activates better collaboration. CDE also ensures several benefits such as ownership of information within the CDE remains with the originator, it supports better decision making as information across the projects minimizes the delay.

BENEFITS OF INTRODUCING CDE PLATFORMS

CDE also facilitates easy exchange of models and data between project team members based on a clear data structure, common naming convention and standardized workflow. This provides greater reliability of data as information has to go through audit trails and validation. Excess time spent searching, sharing, and coordinating information can get reduced significantly. CDE brings several benefits when it is implemented correctly and in a standardized manner. Therefore, CDE strategy shall be considered and developed well before the start.

INTEGRATION OF CDE WITH OTHER APPLICATIONS

CDE can be further integrated with applications and functions to browse the models, clash detection, GIS integration, Scan to BIM activity, IOT Integration, time and cost planning, virtual and augmented reality integration, block chain integration for claims and dispute resolution, virtual meetings, design, construction and asset management activities.

KEY FOCUS AREAS TO SUPPORT DIGITAL TRANSFORMATION IN INDIAN AEC SECTOR

Building design and construction industry of India has now realized that BIM and CDE improves traditional business processes. Essentially, traditional building methods need an overhaul in terms of proper task preparation and planning on the construction site, which renders control over the entire operation. As a result, building owners and developers in the Indian construction industry are beginning to require BIM, CDE and other digital technologies on projects. BIM and CDE operates on a highly collaborative mechanism, which makes possible the planning, development, design, and construction of a structure or building within a 3D model for Clients, consultants, contractors, manufacturers, and other industry players. However, there are few challenges that needs to be addressed for effective digital transformation to happen in Indian construction and infrastructure sector.The key challenges are discussed here.

- Establishing BIM and CDE Strategies in Public & Private Entities: The adoption of BIM and CDE is accelerating across the public and private sector of the Indian Architecture, Engineering and Construction (AEC) industry. Despite many advantages of BIM and CDE in the entire project lifecycle including operations, the use of it is very slow in India. Within these sectors earlier adaptors are being design and engineering firms, followed by construction and then to a little extent at facility management firms. For any investment in BIM and CDE to be sustainable, the consistent development and use of it across multiple building types and across a wide range of government projects and agencies is essential. This essentially creates the need to develop structured and well-established BIM and CDE strategies for Indian AEC firms to address the key issues of diverging use of other national standards and regulations which are not directly relevant to AECoperating environment in India.

- Stakeholders Collaboration in CDE dynamic environment: Non-Strategic and inefficient data management poses several challenges such as resistance in information exchange, poor data quality and lack of consistency, ultimately leading to rework, time-wastage, and reduced productivity. Considering all players involved in all the phases of life cycle of an asset, the amount of information generation, collection, managing and dissemination of the information can be an intricate process issue, as the information flow between the stakeholder is not standardized.
- Integration of BIM and CDE technologies & unified processes: The term "integration" can represent many things. Exporting data from various BIM technology platforms into a standard format (such as COBie or IFC) through a single repository and exporting it into another application are few forms of integration such as BIM with CMMS, BAS (IoT data), & GIS etc. With the current level of technology, BIM is delivered in parts during design & construction. BIM can provide accurate and complete data from design to operations. In present Indian scenarios such data are handled independently from various platforms and are not easily accessible and integrated for the AEC firms who opted for BIM in their projects. To some extent little benefit is realized with the use of CDE. To facilitate transparency and open accessibility on BIM, it is critical that the data within BIM and other non-BIM applications be integrated into the central information management repository so that data provides direct productivity and quality improvements to O&M teams, post-handover.
- Applicability and affordability of CDE platforms: The affordability of CDE platforms is another major challenge. Today, in the Indian projects we use different processes and products (software) for BIM and CDE implementation. Managing dissimilar processes across the projects is often troublesome and costly for Indian AEC companies. Additionally, the commercially available CDE tools are very expensive. SMEs are a large part of our Indian construction Industry serving major contractors, consultants, and vendors. Affordability of such costly software is often difficult for small and medium-sized subcontractors and third-party vendors. The impact of such high investment may hinder the wide adoption of BIM and CDE in the Indian AEC sector. Even if companies decide to have BIM and CDE in their project lifecycle envisaging a greater future benefit, it is now evident that one BIM tool or process is not useful for different application areas (infrastructure or buildings). Also, the use of various tools by different stakeholders in a project may fail to reap the unified benefit of the BIM application while solving the issues of interoperability.
- Contractual dispute and litigation: The forms of contracts prevalent in India are silent on BIM which leave the users uncertain as to the risks and obligations associated with the adoption of BIM and CDE platforms. Given that BIM and CDEare innovative method being introduced to the industry, lack of contractual mechanisms to deal with the situations arising out of its implementation raises special contractual and legal challenges making a fertile ground for disputes.
- Lack of skilled professional to operate BIM & CDE platforms: Nowadays, mega projects are mostly located in developing countries. And outsourcing of engineering works has been relocated to overseas facilities which are able to offer lower wages for the best value. The success of such a construction project depends on the ability of individuals to work together in an open and trustful environment. To up-skill AEC discipline students for these works, tertiary education programs need to be re-designed to discuss unique project types, with the application of innovative means and methods. BIM and CDE platforms promote trans-disciplinary, inter-level, multinational collaborations with different project stakeholders across the project life cycle.

CONCLUSION

There is a need for future development of implementing BIM and CDE for the AEC industry by assessing proper digital transformation in terms

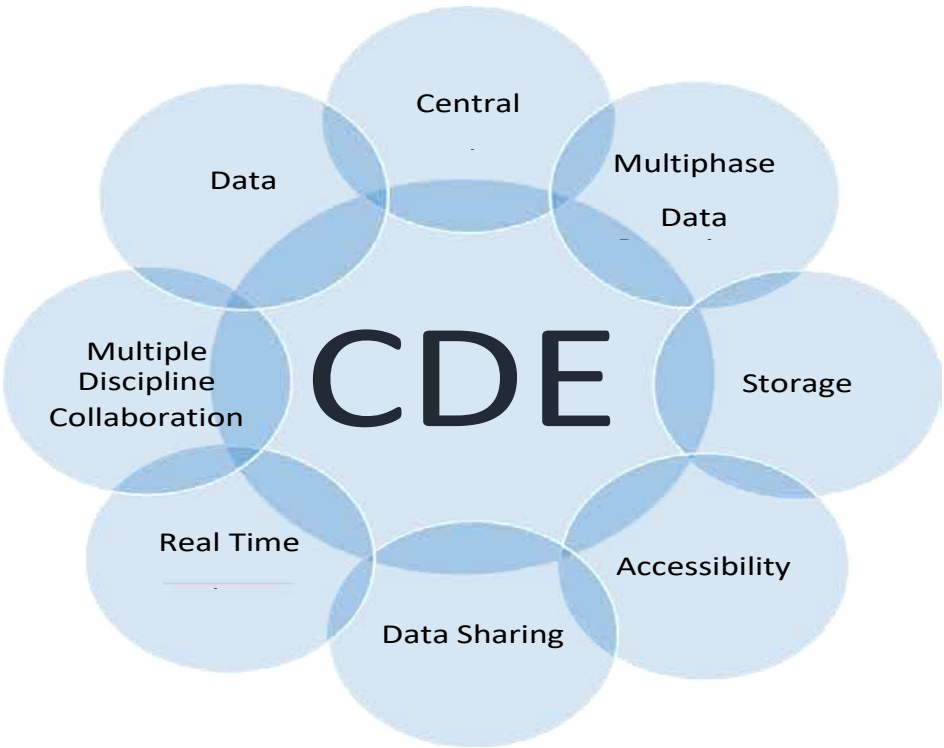
of people, process, and technology adoption. Effective application of BIM and CDE platforms has been monitored and measured at each stage of its implementation in the entire project lifecycle. Periodic audits and support to be provided to the AEC industry for its implementation and utilization. In order to enable implementation of BIM and CDE platforms, the standards should form part of the client/owner's requirements issued at the tender stage and should also form part of the contract. Alongside the choice of the procurement model, a decision regarding who carries the responsibility pertaining to the management of the CDE should be made.

"COMMON DATA ENVIRONMENT FOR INFRASTRUCTURE PROJECT MANAGEMENT"

Nitesh Saluja*

In today's fast moving world, people like to accomplish every task in fraction of time and desire to have all the information available on fingertips. With the advancement of technology and availability of online platforms, it has become easier for people to grow their network and access the latest information. With the expansion of Artificial Intelligence, most of the tedious task in various industries have been replaced by automated processes and hence increasing the productivity and performance.

Similarly, Construction Industry has also been revolutionised with the introduction of Building Information Modelling (BIM) and Common Data Environment (CDE). It brings Architect, Engineers, Contractors, Fabricators and other construction professionals onto a single platform and enhances collaboration, which leads to reduction in rework, quality improvement, and time saving and cost effective. Common Data Environment (CDE) is an online platform, which acts as a centralized database for storing, work sharing and data extraction of BIM Model. It allows collaboration of digital models from multiple disciplines like Architecture, Structure, and MEP. It is essential to store and manage the project-related data at a single place where everyone can access the data. Common Data Environment makes it possible to collect, manage and access the construction project data from a commonplace.



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- **Central Database:** The data for a construction project is stored, managed, and accessible in Common Data Environment, which acts as a secured digital warehouse. Due to improved data security, the CDE in BIM provides excellent encryption and permits data access to only those who are given authorization.
- **Multiphase Data Repository:** CDE allows users belonging to various phases from conceptual/planning stage of the project until Operations and Maintenance stage. It permits everyone to participate and use the construction data as per their requirements.
- **Storage:** All of the data for a construction project is put together by CDE from different sources including BIM Models, Companies Spreadsheet, Design details, RFI details, MOM, Project Schedule, Analysis, Monitoring Data and many more.
- **Accessibility:** CDE is easily accessible by anyone, even from smartphones, provided the person is granted access. The information can be go through at any moment of time, even on the go.
- **Data Sharing:** CDE allows multiple users to work simultaneously on single file and let everyone save their modifications. It also contain any reference information related to the project shared by any stakeholder.
- **Real Time Updation:** CDE ensure to provide up-to-date data of every available element property, which leads to reduction in mistakes and improved communication.
- **Multiple Discipline Collaboration:** Being a single source of truth for construction project, CDE allows the collaboration of various discipline on single platform so that it can be visualised and analysed before executing the work at site.
- **Data Extraction:** CDE helps to extract the data such as material take off, quantum required to execute the work during a particular period, any kind of information related to any element in the project.

CDE, a collaborative environment, where all stakeholders in project share their feedback in form of markups and can assign their reviews to one individual or a group together. It benefits construction industry to completely revolutionize how to gather and utilise the enormous amounts of data that these projects generate.

CDE provides real-time access to all stakeholders involved in the project. It acts as a central hub for entire information related to the project. It is updated on real-time basis, hence leading to more reliable decision making.

BENEFITS:

- **Minimal Design Changes leads to Cost Saving:** Finding efficiencies in producing coordinated information, reducing both time and cost. Providing greater certainty to coordination checks by ensuring models are correct without issues, like clashes between models.
- **Accessibility of Real Time Updated information:** It connects teams, models, and project data in one environment, ensuring a single source of project truth where project participants only have access to what they have authorized to have access to. Project teams can extract selections of the most recent approved information and data from shared areas.
- **Quality Assurance:** A well-utilized common data environment enhances a project's overall quality and efficiency. Accessible data for all maximizes transparency, reduces rework, and improves decision-making. Effectively utilizing data enables a culture of continuous improvement, with projects delivered better and faster, propelling a company forward.
- **Efficient Supply Chain Management:** It assists in analysing and comprehending the material requirement far before it is really required at the site due to coordination among BIM Model and Time Schedule.
- **Regular Tracking/ Analysis of the project:** Since all the updated information is readily available to all stakeholders, it helps in keeping constant check on project progress.
- **Collaborative Work Environment:** It provides a centralized platform for storing, managing, and sharing project-related data, which can help to improve collaboration and communication among project team members. This can help to avoid errors and delays.
- **Enhance Decision Making:** CDE provide a transparent and auditable record of all project-related data and activities, supporting transparency and accountability among stakeholders.

We, at Tata Projects, are using CDE in our projects to maximize the efficiency of our work. It helps us in better understanding the issues/conflicts and achieving the tight timeline of the project using the real time monitoring from all stakeholders.

With the help of BIM 360, our consultants, sub-contractors and site personnel are continuously interacting with the design team stationed at office. It helps us in reviewing clashes, identifying the site hindrances and taking apt decisions to accommodate the same.

Using the platform, we have incorporated our BIM Model with the baseline schedule, and it helps us in visualising plan vs achieved in more understandable form. Hence, it provides us real time progress of the project and help us in planning the manpower, material, machineries and site logistic of the project.

Also, it helps our stakeholders to go through the progress update, project analytics and hindrances on real time basis leading to swift and systematic delivery of outcomes.

CASE STUDY PROJECTS:

Noida International Airport

New Parliament Building

- **Noida International Airport**

It is getting developed on area over 110 hectares. It contains more than 4km long each runway and taxiway. It is being constructed in Jewar, Noida. It is aiming to provide a modern and seamless passenger experience as well as a broad range of commercial offerings for business travellers, elderly travellers, and families with young children.

We are using BIM 360 as a Common Data Environment platform during its design and execution stage. Documentation related to the project is systematically stored in the platform and same can be accessed by all the stakeholders at any given time. This helps in keeping the transparency among everyone regarding the project. If any issue or RFI need to be highlighted to the concerned team member, it gets done via the same platform and its status will be visible to everyone. As a coordinated platform, it enables collaboration between various disciplinary models and provides us with a report on any clashes that may have occurred, allowing the team to analyse, examine, and resolve the issues prior to the execution.

- **New Parliament Building**

It is being constructed over 40000 sqm land area with builtup of approx 80000sqm. It is situated near to the Old Parliament Building within the vicinity of 50m. It is being developed to accommodate more people and provide the parliamentarians with much more advanced facilities. We are also using BIM 360 in this project to facilitate collaboration among different discipline models and to provide a clash-free environment for service installation. Being accessible on smartphones also makes it easier to monitor whether the installation done at site follows the coordinated model. It also permits the site individual to mark/ highlight the issues to design team if any site condition is providing hindrance to the progress of the project. It enhances the communication between office team and site team.

Since it contains all the backup files we have worked on, it allows comparing the two versions of file to go through the changes made in the versions. Being a storage house for entire documentation of the project, it permits to incorporate the baseline schedule with the available BIM Model and it unlocked the way of monitoring the construction project. Instead of analyzing Gantt charts or bar charts, we have provided our stakeholders a 3D visualization of the work that was scheduled vs the work that was completed.

With the allowance of data mapping and permission control settings, CDE offers superior data quality and security. Being Centralized, it actually simplifies the data workflows, eliminating the duplicity of progress monitoring and bridging the gap between pre construction, construction and post construction phases.

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