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ISO 19650-Aligned BIM Methodologies for 4D and 5D Project Management of Reinforced Concrete Structural Systems

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Abstract

Day by day, RC (Reinforced Concrete) construction projects are becoming more complex, and they pose significant challenges in terms of coordination, cost control, and schedule reliability. Inefficiencies in traditional project management methods are being highlighted. BIM (Building Information Modelling) emerges as the potential and most accurate solution for those whose use is predominantly restricted to geometric modelling, mostly in the domain of structural engineering. This study is mainly aimed at exploring the potential of ISO 19650-aligned BIM methods to improve 4D (time) and 5D (cost) project management of RC structural systems.

The main aspect of this research is to follow a qualitative and practical approach to thoroughly review the existing standards and literature for BIM implementation. A very structured workflow is followed, right from 3D modelling to the time and cost aspects of RC project management. The BIM tool that is predominantly used is Autodesk Revit to model the project, create a construction sequence, and evaluate and compare costs throughout the project life cycle.

With the implementation of BIM as per ISO 19650, it is observed that information consistency, manual errors in reinforcement documentation, and design coordination are greatly improved. BIM implementation offers a clear visualisation of each step followed in RC project management, right from geometric modelling to time and cost integration. This study describes that implementation of BIM is not just limited to design representation, but with the guidelines of international standards, it can be used effectively as a project management tool for RC structural projects. The proposed workflow is structured as per ISO 19650 guidelines and provides important insights for engineers to enhance planning efficiency, cost predictability, and decision-making in RC construction.

Keywords: BIM, ISO 19650, 4D/5D BIM, Project Management, Cost Control, Construction Planning.

1. Introduction

Major transformation is being observed in the AEC (Architecture, Engineering & Construction) industry, followed by the adoption of BIM. Limitations of traditional project management methods are being highlighted constantly with the increasing scale and complexity of RC projects. BIM enables us to make informed decisions, improve design collaboration, and help to represent the physical environment in a digital format to foresee any expected pitfalls beforehand.

Substantial benefits in reinforcement detailing, coordination, scheduling, and cost estimation can be derived in structural engineering with the use of BIM. Visualisation, Planning Accuracy, and Risk Mitigation are greatly enhanced with 4D (time) and 5D (cost) integration of BIM. It leads us to improved constructability and project reliability. Nonetheless, it is still challenging to adopt BIM in terms of standardization, risk management, and interoperability. ISO 19650 provides us with a structured framework for the standardized adoption of BIM.

In addition to that, with the advent of technologies like Artificial Intelligence, Blockchain, Digital Twins, and Cloud-Based Platforms like Autodesk 360, possibilities with BIM towards predictive analysis, automation, and secured collaboration are continuously being enhanced. Further, these continuous developments are placing BIM as a strategic project management tool for efficient and sustainable structural project delivery.

2. LITERATURE REVIEW

Reviewed literature greatly highlights the fact that in the AEC industry, BIM has emerged as a transformative tool that helps in Scheduling, Risk Mitigation, Cost Estimation, Project Management, and Design Coordination. BIM aids in basic things, such as BBS (Bar Bending Schedule) generation, all the way up to the complex capabilities like providing a secure shared CDE (Common Data Environment) for project stakeholders to perform smooth and reliable collaboration.

BIM's capabilities are greatly enhanced with the integration of its multifaceted dimensions. With 4D (time) and 5D (cost) BIM, it aids in real-time cost monitoring and reducing project delays.

However, the literature review also highlights that the lack of a standardized framework inhibits the adaptability of BIM across regions. This threat is particularly underlined in developing nations.

Overall, the reviewed research suggests that BIM, when combined with its capabilities to the fullest and a solid structural framework like ISO 19650, can be a great enabler and a tool of utmost potential for enhanced and smooth management of RC projects to improve cost efficiency, risk mitigation, and project lifecycle.

3. METHODOLOGY

A. Definition of Scope

This project aims to study the ISO 19650 framework for a structured RC project. An RC structure is modelled in Autodesk Revit along with reinforcement modelling. Further steps in a framework are followed for the model. The level of Detail for the framework study purpose is kept at LOD 350. Level of Details is given as follows:

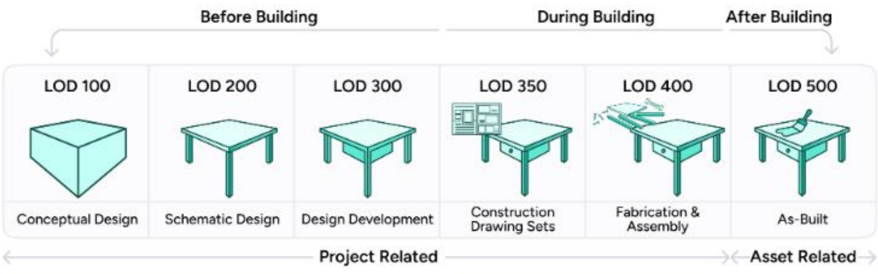

FIG 1: LEVEL OF DETAIL

1. LOD 100 – Conceptualisation
2. LOD 200 – Schematic Design
3. LOD 300 – Detailed Design
4. LOD 350 – Construction Documentation
5. LOD 400 – Fabrication and Assembly
6. LOD 500 – As-Built Conditions

And the ISO 19650-aligned BIM workflow is mapped against the model.

B. IDENTIFICATION AND DOCUMENTATION OF PRACTICAL DELIVERABLES AS PER ISO 19650

- Master Information **Delivery Plan (IDP)**
  - What info is needed
  - When (design/construction stage)
- Model **Naming Convention**
  - Example:
    STR_RC_L3_COL_Rev01.rvt
- CDE **Workflow Diagram**
  - WIP → Shared → Published → Archive

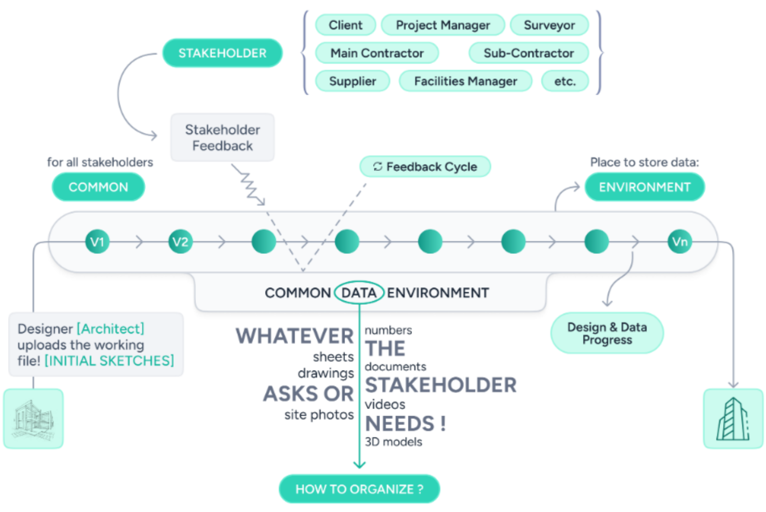

FIG 2: WORKFLOW OF CDE

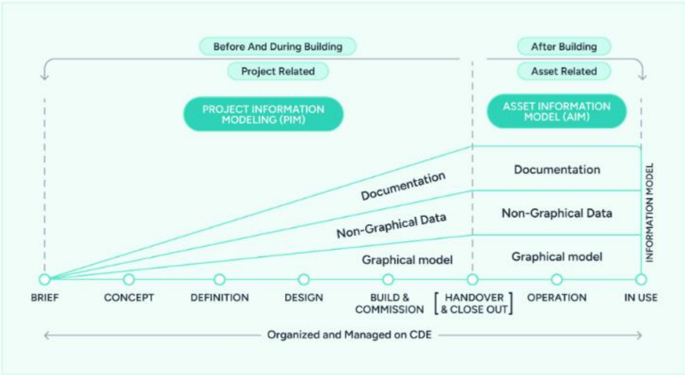

FIG 3: ORGANIZATION AND MANAGEMENT OF CDE

- Responsibility **Matrix**
  - Structural engineer
  - BIM modeler
  - Planner
  - Quantity surveyor

C. MODELLING AND COMPARISON

A 3D Model is developed in Autodesk Revit with the required steps, including placements of –

- Grids, Levels
- Columns, Beams, Slabs
- Foundations
- Reinforcement

Exact Deliverables to be extracted –

- Revit Quantity Take-off Schedule
- Structural Model of the project
- Construction Schedule
- Cost Integration into the Revit Schedule
- Conventional vs BIM comparison to get an overview of resources saved

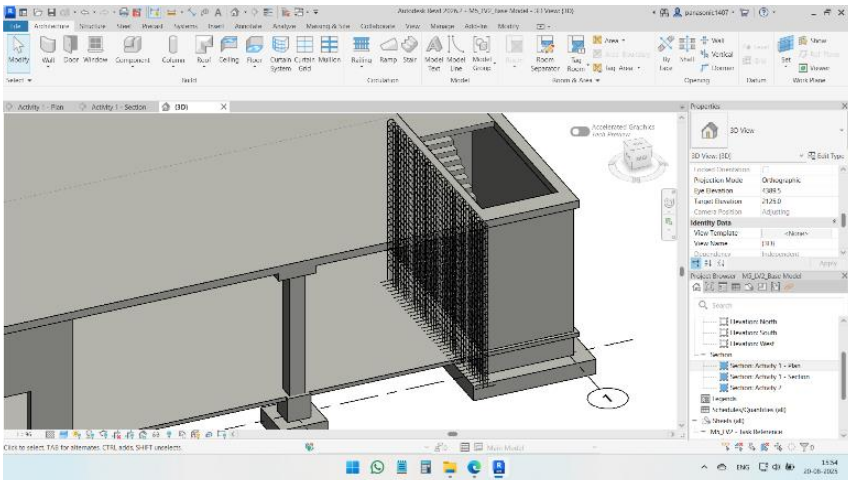

FIG 3: DETAILED REINFORCED MODELLING

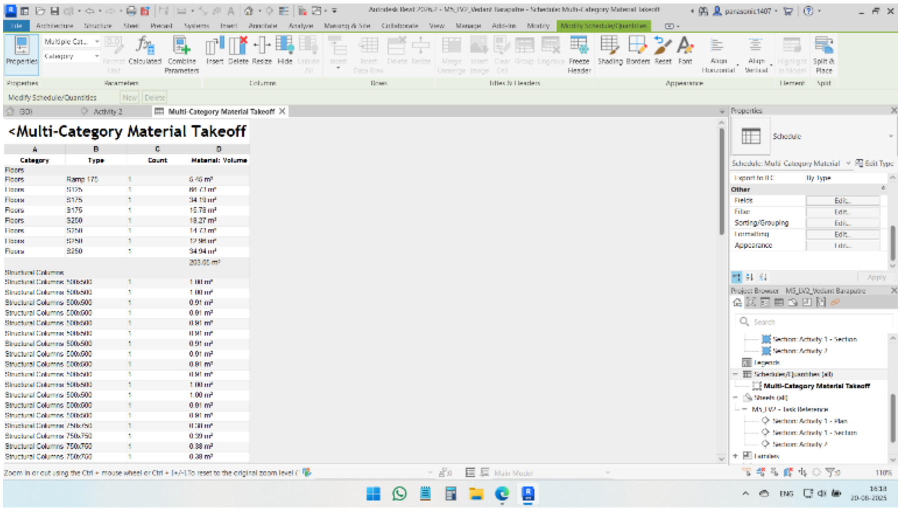

FIG 4: MATERIAL TAKEOFF SCHEDULE

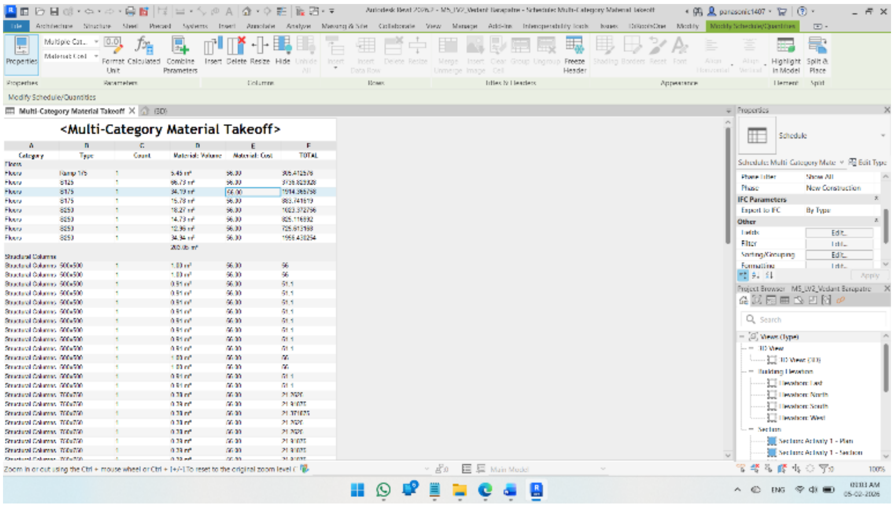

FIG 5: INTEGRATED COSTING CALCULATION

	A	B	C	D	E	F	G
1	TaskID(*)	TaskName	Duration	Start	Finish	3DResourc	Delete
2	ST00020	1_Piles	11	01-12-2023	15-12-2023	0	
3	ST00030	2_Foundations	15	18-12-2023	05-01-2024	0	
4	ST00040	3_Basement	10	08-01-2024	19-01-2024	0	
5	ST00050	4_Ramp	10	22-01-2024	02-02-2024	0	
6	ST00060	5_GF Slab	10	05-02-2024	16-02-2024	0	
7	ST00070	6_Core walls	9	19-02-2024	20-03-2024	0	
8	ST00080	7_Columns 1	6	01-03-2024	08-03-2024	0	
9	ST00090	8_Level 2	10	11-03-2024	22-03-2024	0	
10	ST00100	9_Level 3	10	25-03-2024	05-04-2024	0	
11	ST00110	10_Columns 2	10	08-04-2024	19-04-2024	0	
12	ST00120	11_Level 4	10	22-04-2024	03-05-2024	0	
13	ST00130	12_Level 5	10	06-05-2024	17-05-2024	0	
14	ST00140	13_Columns 3	10	20-05-2024	31-05-2024	0	
15	ST00150	14_Roof 1	10	03-06-2024	14-06-2024	0	
16	ST00160	15_Roof 2	10	17-06-2024	28-06-2024	0	

FIG 6: AUTOMATED CONSTRUCTION SCHEDULING OUTPUT

4. CONCLUSION

This project concludes that BIM methodologies aligned with the ISO 19650 framework, when applied to RC Structural systems, greatly enhance not only 3D modelling capacities but also effective project management through efficient cost control, construction sequencing, and precise quantity take-offs. The proposed workflow deciphers BIM's credibility as a strategic tool for project management, serving today's versatile and complex demands over traditional project management tools and techniques.

The core conclusions are:

BIM as a Project Management Tool: The main emphasis of the project is that BIM is not merely a 3D modelling tool; when implemented with the ISO 19650 guidelines, it can be successfully deployed as an integrated project management system, with the flexibility to enhance its capabilities as needed. This can be done by adopting a federated model, i.e. integrated model of different disciplines such as Architectural Structural HVAC, etc. That facilitates a single and credible source of information to different stakeholders engaged in a project, ultimately reducing dependence on the fragmented sources of information.

Effectiveness of ISO 19650 in Structural BIM workflows: As discussed earlier main hurdles in adopting BIM is lack of uniformity and standardized processes to be followed by stakeholders across boundaries. That is greatly facilitated by the advent of ISO 19650. It provides a standard structural workflow to be followed by all in the same manner to rule out anomalies. File naming conventions, operating in a CDE (Common Data Environment), Drafting and Implementation of Project Documents like MIDP (Master Information Delivery Plan), BEP (BIM Execution Plan). This greatly helps in making structural data auditable, traceable, and standardized.

Enhancement in Reinforcement Detailing Accuracy: Integrated approach and use of Federated models in BIM allows us to work on a single file to get varied outputs. 3D Modelling in Revit, along with precise Reinforcement Modelling, allows us to get automated BBS generation. It rules out the possibility of manual errors, and it also facilitates better visualization of constructability and congestion issues in reinforcement detailing.

Value of 4D BIM (TIME) in Construction Planning: Construction delay is still a major threat and a chief impactor on construction finance and budgeting of a project. With the extension of 4D to the existing BIM model clear visualization of the construction sequence is facilitated. It can be used effectively to get early warning signs of any issues while construction planning and logical task sequencing.

Reliability of 5D BIM (COST) for Cost Control: To improve cost predictability and transparency, Federated Models in BIM can be directly linked to cost parameters. This again rules out the need for manual intervention and automates the process, ultimately giving accurate and timely results. Which means faster quantity take-offs, improved budget monitoring, cost revisions, reduced calculation mismatch, and fewer surprises.

Reduction in Rework and Documentation Effort: As the construction sequencing is done in advance, before actually deploying it, physical clash detection can be effectively visualised, reducing rework. For documentation, standardized templates are provided with the ISO 19650 framework along with guidelines to deploy CDE (Common Data Environment).

Feasibility in the Indian Context: India does not mandate BIM adoption, unlike some Nordic countries, but awareness is definitely on the rise. BIM as a strategic tool of pragmatic importance will certainly be deployed in Indian RC projects. Although certain challenges are common, such as high adoption cost, that is compensated for profitably with the savings through avoided rework and streamlined data complexities.

Limitations: This study is solely done on software modelling. It is a case study to show how BIM can save multiple efforts to effectively save time and resources in RC Structural Projects. It is a partial adoption of the ISO 19650 standard to contribute towards standardization and the adoption of BIM in India. Despite these limitations, all the conclusions remain valid for demonstrating methodology and comparative advantages over traditional project management.

References

1. Khalid, M. A., Hassan, M. U., Ullah, F., & Ahmed, K. (2024). Integrated building information modeling and blockchain system for decentralized progress payments in construction projects. Journal of Engineering, Design and Technology, ahead-of-print. Emerald
2. Hijazi, A. A., Perera, S., Alashwal, A. M., & Calheiros, R. N. (2023). Developing a BIM Single Source of Truth Prototype Using Blockchain Technology. Buildings, 13(1), 91. MDPI
3. (Review) “When BIM meets blockchain: a mixed-methods literature review.” (2024). Journal of Civil Engineering and Management. journals.vilniustech.lt
4. (Review) “Building Information Modeling (BIM), Blockchain, and LiDAR Applications in Construction Lifecycle: Bibliometric, and Network Analysis.” (2024). Buildings, 14(4), 919. MDPI
5. (Review) “Integrating BIM and Blockchain across construction lifecycle and supply chains.” (2023). Computers in Industry. ACM Digital Library
6. (Conceptual) “Principles for Sustainable Integration of BIM and Digital Twin Technologies in Industrial Infrastructure.” Sustainability, 16(22), 9885. MDPI
7. (Conceptual) “From Building Information Modeling to Construction Digital Twin: A Conceptual Framework.” (2024). Construction Digital Twin framework. Taylor & Francis Online
8. Celik, Y., Petri, I., & Barati, M. (2023). Blockchain-supported BIM data provenance for construction projects. Computers in Industry, 144, 103768. MDPI
9. Cascone, S. (2024). Eco-innovative construction: Integrating green roofs design within the BIM framework. Sustainability, 16, 1967. MDPI 17
10. Javaherikhah, A., Valiente López, M., & Mohandes, S. R. (2023). Developing an inspector-centric blockchain-enabled conceptual framework for BIM management in Mars buildings. Buildings, 13(11), 2858. jau.vgtu.lt
11. Hsu, C. L., Wang, J. T., & Hou, H. Y. (2023). A blockchain-based parametric model library for knowledge sharing in BIM collaboration. Journal of Construction Engineering and Management, 149(11), Article 04023107. jau.vgtu.lt

12. Hunhevicz, J. J., Motie, M., & Hall, D. M. (2022). Digital building twins and blockchain for performance-based (smart) contracts. Automation in Construction, 133, Article 103981. jau.vgtu.lt
13. Husin, A. E., & Priyawan, P. (2023). Indonesia regulation-based green cost efficiency using SEM-PLS and Blockchain-BIM. Journal of Sustainable Architecture and Civil Engineering, 33(2), 96–112. jau.vgtu.lt
14. Husin, A. E., et al. (2023). Renewable energy approach with Indonesian regulation guide using Blockchain-BIM for green cost performance. Civil Engineering Journal, 9(10), 2486–2502. jau.vgtu.lt
15. Jia, J., Zhang, M., & Yang, G. (2022). Factors influencing BIM integration with emerging technologies: Knowledge coupling perspective. Journal of Management in Engineering, 38(2), 04022001. jau.vgtu.lt
16. Jiang, H., Yun, L., & Li, B. (2022). Framework for blockchain-enabled building information modeling. In FICC 2022, Lecture Notes in Networks and Systems, 438, 832– 842. jau.vgtu.lt
17. Kamel, M. A., Bakhoum, E. S., & Marzouk, M. M. (2023). A framework for smart construction contracts using BIM and blockchain. Scientific Reports, 13, 10217. jau.vgtu.lt
18. Kang, J. (2022). Convergence analysis of BIM & blockchain technology in construction industry informatization. In ICSSIT 2022, pp. 256–259. jau.vgtu.lt 18
19. He, Wang, & Zhang (2023). Generative AIBIM: An automatic and intelligent structural design pipeline integrating BIM and generative AI. Preprint. arXiv
20. (Review/Systematic) "Integrating blockchain with BIM: a systematic review based on a sociotechnical system perspective." (2023). Emerald Insight. Emerald