JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Enhancing Structural Design and Modeling Efficiency in BIM through the Synergy of Microsoft Excel and BIM Tools Using Dynamo

[1]Inam Ullah, [2]Muhammad Waseem

[1]Post Graduate Student, [2]Assistant Professor
[1]University of Engineering and Technology Peshawar,
Peshawar, Pakistan

Abstract : This paper explores the integration of Microsoft Excel and BIM tools using Dynamo to enhance design efficiency in the Architecture, Engineering, and Construction (AEC) industry. A survey was conducted among AEC professionals to identify barriers to BIM adoption, with a focus on perceived complexity and the potential of automation. Based on the survey findings, a dedicated Dynamo library, Inam Structural Design, was developed to automate structural design and modeling processes. The library includes 15 customized nodes for modelling structural geometry, rebar detailing, manual design checks, and 4D BIM modelling. The library has been downloaded over 300 times and has been introduced to students through training sessions, demonstrating its potential to improve BIM adoption and workflow efficiency.

Keywords: BIM, Dynamo, Automation, Structural Design, AEC Industry

1. INTRODUCTION

Building Information Modeling (BIM) has revolutionized the AEC industry by enabling improved collaboration, accuracy, and efficiency. However, the adoption of BIM is often hindered by perceived complexity, high initial costs, and a lack of skilled professionals. This paper addresses these challenges by proposing the use of visual programming tools like Dynamo to automate complex BIM tasks i.e., structural modeling as per codal requirements. A survey was conducted to understand the barriers to BIM adoption and the potential of automation. Based on the findings, a Dynamo library was developed to streamline structural design and modeling processes, demonstrating the use of visual programming Dynamo. A case study was also performed based on this Dynamo Library. A structural model was developed utilizing the Dynamo library, incorporating rebars. Subsequent detailing and quantification of rebars were performed. Later on, Microsoft Excel and BIM tools can also be linked via Dynamo for better coordination and efficiency.

2. LITERATURE REVIEW

Construction projects globally are increasingly adopting Building Information Modeling (BIM) to improve efficiency, collaboration, and decision-making throughout the project lifecycle [1]. BIM enables architects, engineers, and construction professionals to create and manage a digital representation of the project. In Pakistan, despite the potential benefits of BIM for logistic optimization and clash detection, its adoption is limited [2]. It greatly increases construction efficiency throughout project BIM come with tremendous benefits for Architecture, Engineering and Construction (AEC) professionals e.g. logistic optimization clash detection and resources optimization [3]. Through BIM we can also do Building Energy Measurements and optimizations [4], [5].

The integration of Building Information Modelling (BIM) with optimization algorithms has emerged as a critical area of research aimed at enhancing structural design and modelling efficiency. Previous Research have emphasize the pivotal role of Structural Design Optimization (SDO) in improving design quality, cost efficiency, and sustainability within construction projects [6]. Their study highlights the necessity for early-stage collaboration among project stakeholders, facilitated by innovative technologies like BIM and optimization algorithms. Furthermore, in another study a workflow is propose to synergizes visual programming (VP) with BIM tools, specifically through Dynamo, to optimize structural elements platforms, enabling seamless data exchange and enhancing the efficiency of structural analysis [7]. The combination of artificial intelligence, such as genetic algorithms, with BIM and VP allows for a more streamlined approach to structural design, minimizing material consumption and environmental impact. By leveraging tools like Microsoft Excel alongside BIM applications, researchers can further refine data management and analysis processes, ultimately leading to improved modelling efficiency. This literature indicates a promising direction for future research, focusing on the integration of various digital tools to enhance structural design outcomes in the AEC industry. Such as trusses. This methodology underscores the importance of interoperability between software

3. METHODOLOGY

I. Survey Design and Findings

A survey was conducted among AEC professionals to gather insights into BIM adoption, perceived complexity, and the role of automation. The survey included questions on:

a) Current BIM Usage and Implementation Levels.

AEC professionals were asked about how much they use BIM and to what extent BIM is implemented in their organizations. 53.6 % of the participants were not using BIM but were planning to adopt as shown in Figure 1

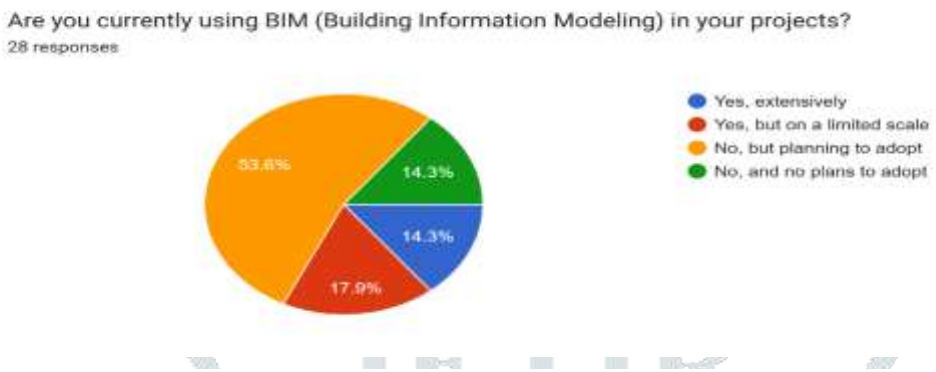

Figure 1

Among 40 .7% participants were those where BIM was not implemented in their organizations/company as shown in the Figure 2

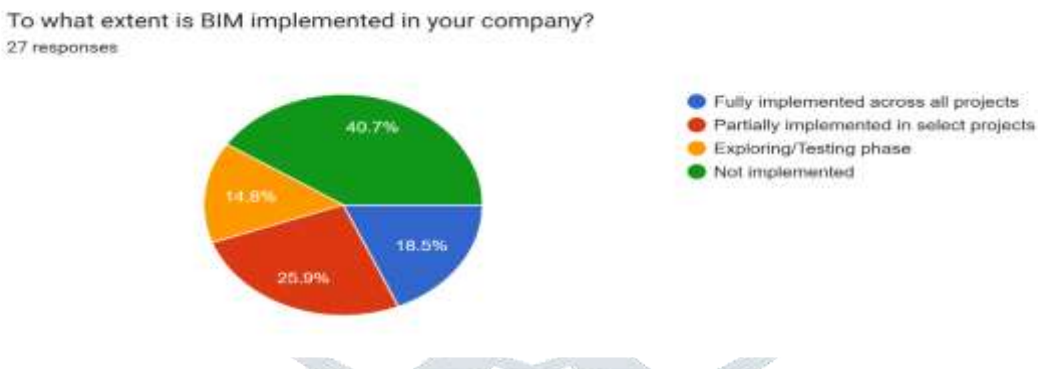

Figure 2

b) The Primary Barriers to BIM adoption

The participants were also asked about the Primary barriers to BIM adoption in their companies 63% participants chooses lack of skilled professionals while 44.4 % chooses the perceived complexity of BIM tools as shown in the Figure 3.Author in this paper is trying to solve these barriers. Also, many participants point out to that the Limited BIM Implementation is because perceived complexity and high initial costs. And that there is a Need for Training: Professionals emphasized the importance of training and resources to mitigate the complexity of BIM tools as shown in the Figure 4.

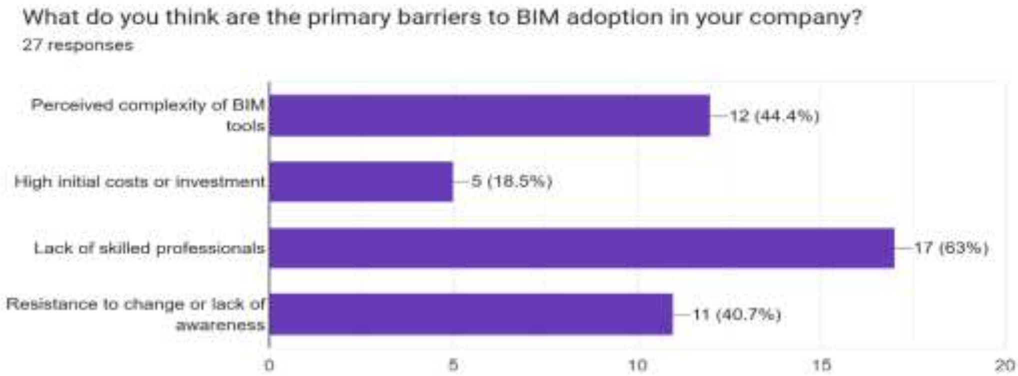

Figure 3

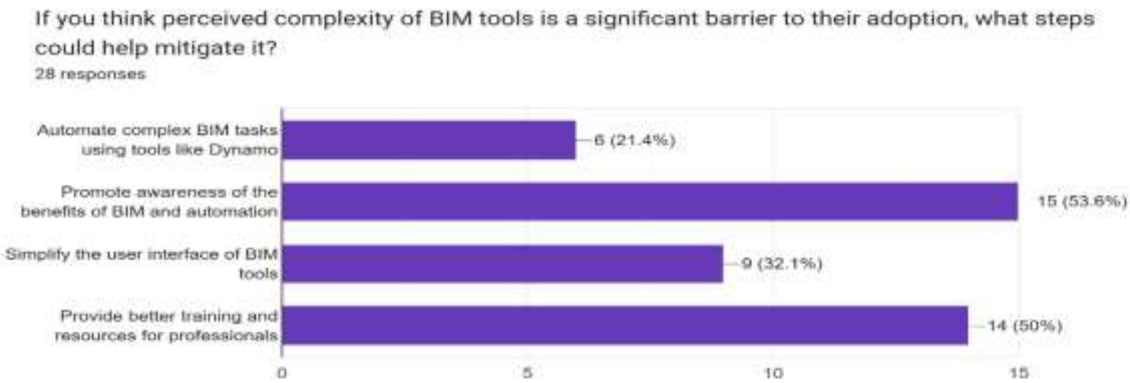

Figure 4

c) The potential of automation tools like Dynamo to improve workflow efficiency.

As shown in the Figure 5 Almost all the respondents agrees that automation of complex tasks using Dynamo can bring numerous benefits for the AEC professionals. Also in the Figure 6 Over 80% of respondents believed that automating BIM tasks using Dynamo would significantly improve efficiency and reduce manual errors

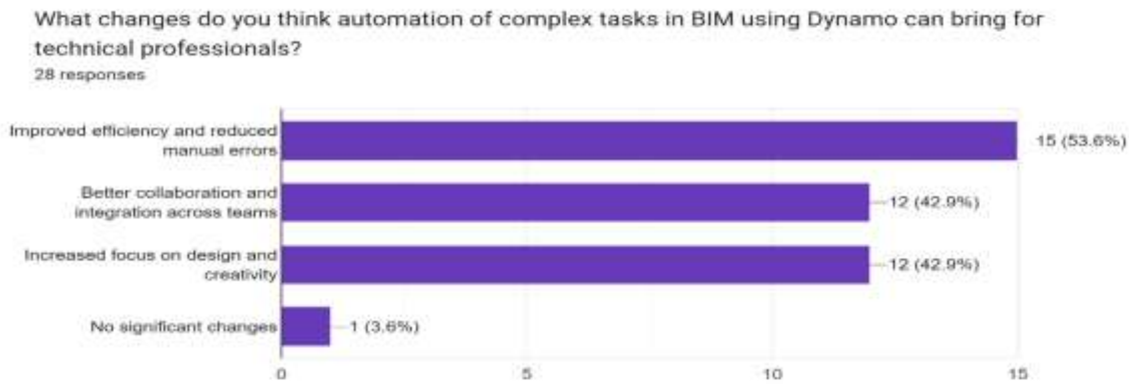

Figure 5

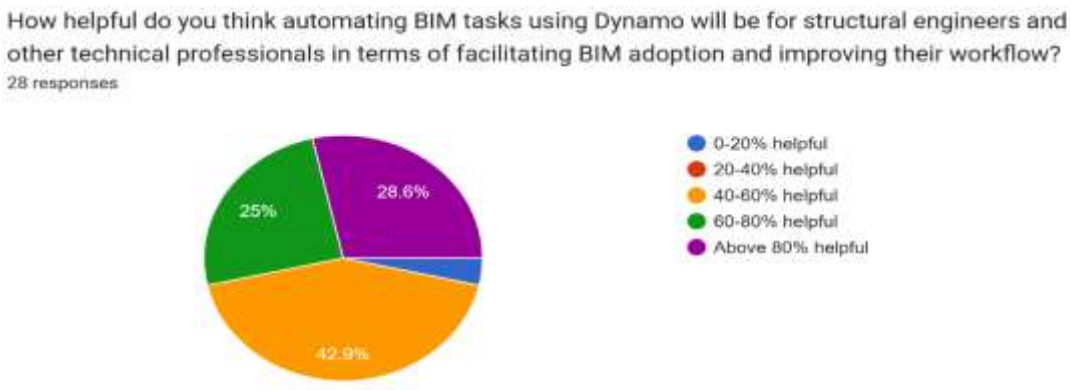

Figure 6

II. Development of the Dynamo Library

Based on the survey findings, a dedicated Dynamo library, Inam Structural Design, was developed as shown in the Figure 7 . The library includes 15 customized nodes designed to:

- Automate structural geometry modeling and rebar detailing.
- Perform manual design checks.
- Facilitate 4D BIM modeling.

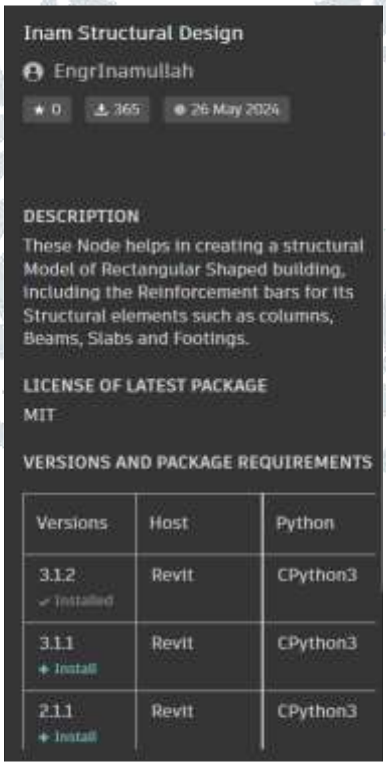

Figure 7

The library was published and made available for download, with over 300 downloads recorded to date as shown in the Figure 7 Additionally, two training sessions were conducted to introduce students to the library and visual programming concepts.

4. Results and Discussion

I. Case Study

The *Inam Structural Design* library has demonstrated significant potential in enhancing BIM adoption and workflow efficiency. A graph can be created as shown in Figure 8. It can be downloaded from this source [8]. The graph consists of five groups of nodes. The first group of nodes represents the input nodes. The second group consists of nodes required to create the structural model without rebars. The third group of nodes is responsible for correcting the geometry. The fourth group divides the geometry into different faces, and finally, the fifth group models the rebars inside the structural model based on the required design.

Before inputting any data into the graph, the third and fourth groups of nodes should be frozen. Depending on the project, some inputs are required in the first group of nodes, such as the number and spacing of grids in the x and y directions. As this data is entered, a structural model is generated. Then, as mentioned earlier, the third group of nodes is unfrozen to correct the geometry. After the geometry has been corrected, these nodes are frozen again. For rebar modeling, the fourth group of nodes is then unfrozen, enabling the generation of rebars according to the required design.

A pilot project with four grids in the x-direction and three grids in the y-direction, with uniform spacing, was modeled in Autodesk Revit using this graph, as shown in Figure 9 and Figure 10. The modeling and quantification of structural elements, which are typically labor-intensive tasks, can be completed within seconds using Dynamo, as demonstrated in Table 1

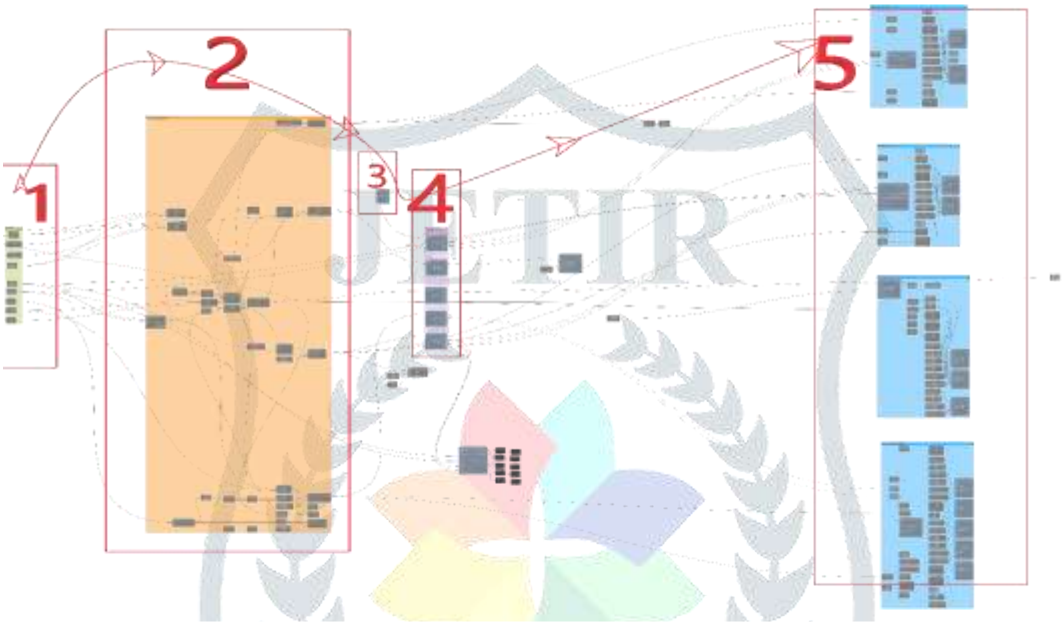

Figure 8

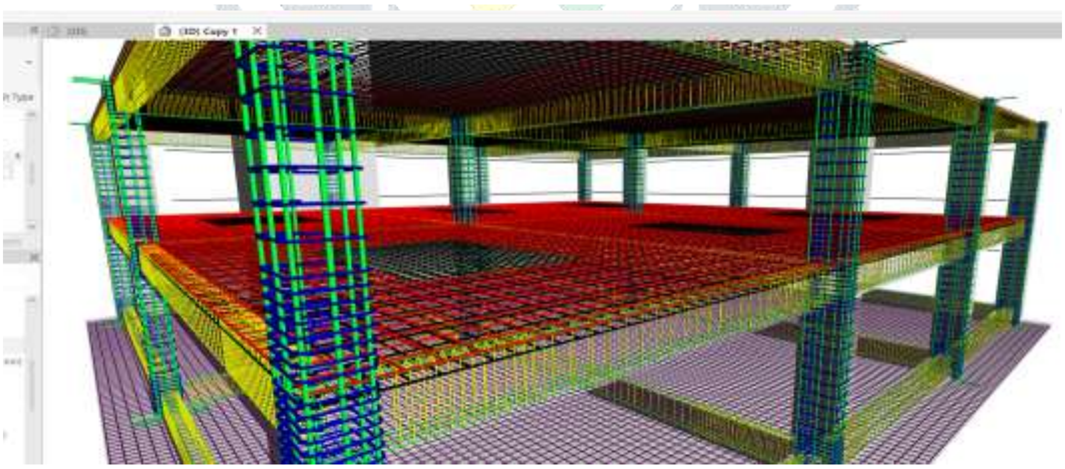

Figure 9

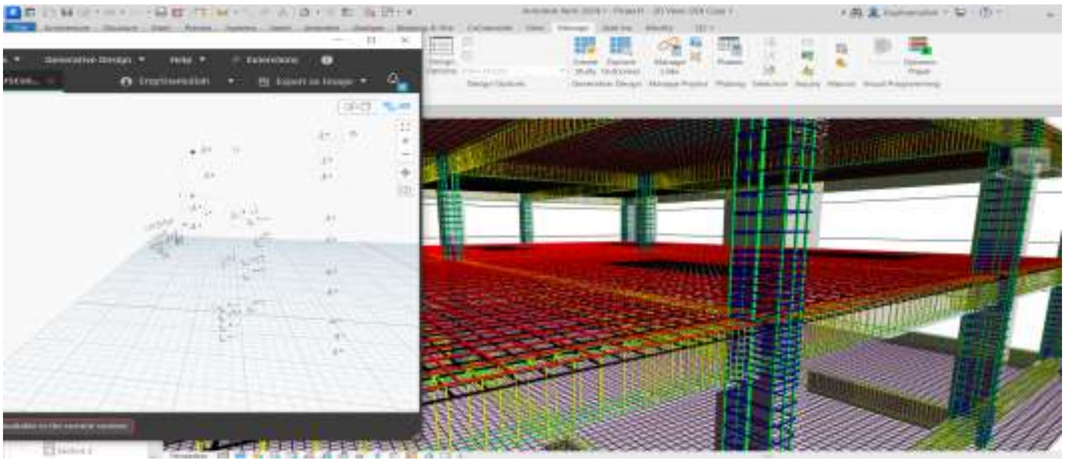

Figure 10

Table 1

Rebar Schedule					
Family and Type	Host Category	Comments	Reinforcement Volume in^3	Counts	Total volume in^3
Floor					
Rebar Bar: #6	Floor	BottomSlabRebars	322.06	420	135265.2
Rebar Bar: #6	Floor	RaftRebars	349.01	228	79574.28
Rebar Bar: #6	Floor	TopSlabRebars	29.82	112	3339.84
Rebar Bar: #6	Floor	TopSlabRebars	43.07	92	3962.44
Rebar Bar: #6	Floor	TopSlabRebars	72.45	112	8114.4
Rebar Bar: #6	Floor	TopSlabRebars	107.8	46	4958.8
Rebar Bar: #6	Floor	TopSlabRebars	322.06	194	62479.64
Structural Column					
Rebar Bar: #8	Structural Column	RebarsColumns	221.87	7	1553.09
Rebar Bar: #6	Structural Column	RebarsColumns	127.56	12	1530.72
Rebar Bar: #8	Structural Column	RebarsColumns	232.47	77	17900.19
Rebar Bar: #6	Structural Column	TiesRebarsColumns	37.38	648	24222.24
Structural Framing					
Rebar Bar: #3	Structural Framing	BottomRebarsBeam	82.28	27	2221.56
Rebar Bar: #3	Structural Framing	BottomRebarsBeam	82.95	36	2986.2
Rebar Bar: #3	Structural Framing	StirrupRebarsBeam	7.38	2973	21940.74
Rebar Bar: #3	Structural Framing	TopRebarsBeam	82.28	27	2221.56
Rebar Bar: #3	Structural Framing	TopRebarsBeam	82.95	36	2986.2
Grand total: 5047				5047	375257.1

II. Impact of the Dynamo library

As a result of this Pilot project, following deductions can be incurred.

- Enhanced Collaboration:

The library facilitates better integration between design and construction teams. As in case of this pilot project, Microsoft Excel can be linked with the inputs of this graph a designer will be able to just manually input data in Microsoft Excel and in accurate BIM would be created in Autodesk Revit

- 4D BIM Modelling:

Also, in inam structural design there is a node which can be beneficial in Integrating Microsoft Excel with Autodesk Navisworks responsible for Timelier Simulations i.e. (4D BIM) Integration of time-based project planning.

- Increased Focus on Creativity:

By automating complex tasks, professionals can focus more on design and innovation.

III. Training and Adoption

The training sessions conducted with students highlighted the importance of visual programming in bridging the gap between traditional CAD workflows and BIM. All the required materials and files were provided to the students [8] Participants reported increased confidence in using Dynamo and expressed interest in further exploring automation tools.

5. Conclusion

This paper highlights the potential of integrating Microsoft Excel and BIM tools using Dynamo to enhance design efficiency in the AEC industry. The development of the Inam Structural Design library addresses key barriers to BIM adoption, such as perceived complexity and lack of training. The library's success, evidenced by its widespread adoption and positive feedback from users, underscores the importance of automation in driving BIM adoption and improving workflow efficiency.

6. References

1. Akdag, S.G. and U. Maqsood, *A roadmap for BIM adoption and implementation in developing countries: the Pakistan case.* Archnet-IJAR: International Journal of Architectural Research, 2019. **14**(1): p. 112-132.
2. Fatima, A., M. Saleem, and S. Alamgir. *Adoption and scope of building information modelling (BIM) in construction industry of Pakistan*.
3. Crowther, J. and S.O. Ajayi, *Impacts of 4D BIM on construction project performance.* International Journal of Construction Management, 2021. **21**(7): p. 724-737.
4. Ullah, I., et al., *Energy Wastage and Recovery Options in Buildings using Blower Door and Building Information Modeling*, in *4th International Conference on Emerging Trends in Engineering,Management and Sciences" September 29-30 (ICETEMS-2021) Peshawar, Pakistan*. 2021.
5. Ullah, I., et al., *Case Study: Analyzing Energy Use Intensity for Energy Efficiency and Optimization in an Educational Building*, in *5th international conference on sustainable energy technologies (ICSET 2023) Peshawar,Pakistan*. 2023
6. Afzal, M., et al., *Towards BIM-Based Sustainable Structural Design Optimization: A Systematic Review and Industry Perspective. Sustainability 15 (20): 15117*. 2023.
7. Altun, M. and A. Akcamete. *A method for facilitating 4D modeling by automating task information generation and mapping*. Springer.
8. ullah, I., *Autodesk Revit and Dynamo Files https://doi.org/10.5281/zenodo.14846674*. 2025.

7. Author Profile

Inam Ullah received his B.S. degrees in Civil Engineering. He has conducted research on BIM automation, developed the "inam structural design" Dynamo library, and trained professionals in visual programming and automation. His work aims to enhance BIM implementations as well Structural Modelling and Design efficiency.