

ECOFIX- A PYREVIT PROTOTYPE FOR A LEAN AND SUSTAINABLE RENOVATION DECISION SUPPORT TOOL

Narmada Bharadwaj¹, Prasanna Venkatesan Ramani², Mushrifa Ali³, Saran Somapalli Sureshkumar⁴, & Harshitha Tumma⁵

ABSTRACT

Renovation and adaptive reuse offer sustainable alternatives in the construction industry, but are underused due to a lack of integrated decision support tools, which can aid during the design stage. This paper presents Ecofix, a prototype developed using PyRevit, which acts as an integrated sustainable renovation decision support tool inside Autodesk Revit environment. This tool is developed using Python, and it assists designers and engineers to evaluate various retrofit, demolition, demolition with rebuild, retain, and new build scenarios using lean and sustainable design principles. This tool automatically extracts the material and quantity data from Revit, calculates and gives a comparative report for retrofit, demolition, rebuild, reuse, retain and new build. It takes carbon dioxide equivalent, cost, and time required to complete the work based on the quantity selected by the user into account. Ecofix aligns with lean and green by embedding waste-free decision support inside Revit. This tool eliminates lean wastes (information transfer, time, over-processing) by automatically taking Revit quantities and ranking retrofit, demolish, rebuild, and retain options by carbon dioxide equivalent, cost and time. The prototype enables Set-Based Design and material waste elimination through salvage/reuse quantification, prioritising lowest-carbon scenarios while maximising circular economy benefits.

KEYWORDS

Sustainability, lean and green, set-based design, renovation decision support, and digitalisation and lean.

INTRODUCTION

According to the report by World Green Building Council (2019), buildings contribute to 39% of global energy carbon emissions, of which operational emissions account for 28% and materials and construction account for 11%, respectively. Without intervention, embodied carbon from building projects will account for nearly half of global emissions by 2050. Retrofitting can achieve 60–90% embodied emission reductions relative to new construction

¹ Masters Student, School of Civil Engineering, VIT University, Vellore, India, narmada.bharadwaj2024@vitstudent.ac.in

² Associate Professor, School of Civil Engineering, VIT University, Vellore, India, prasanna.venkatesan@vit.ac.in, orcid.org/0000-0002-6924-9520

³ Doctoral Research Scholar, School of Civil Engineering, VIT University, Vellore, India, mushrifa.ali2023@vitstudent.ac.in, orcid.org/0009-0000-3444-5874

⁴ Masters Student, School of Civil Engineering, VIT University, Vellore, India, saran.ss2024@vitstudent.ac.in

⁵ Masters Student, School of Civil Engineering, VIT University, Vellore, India, tumma.harshitha2024@vitstudent.ac.in

(Besana & Tirelli, 2022). Sustainable building renovations are essential, but they are not progressing swiftly due to decision-making dilemmas (Jørgensen et al., 2025). Mainstream parametric design authoring tools are lacking integrated retrofit/demolition assessment capabilities (Khaddaj & Srouf, 2016).

To address this gap, this research introduces Ecofix—a PyRevit-based prototype integrated within Autodesk Revit that enables designers to evaluate retrofit, demolition, rebuild, and retain scenarios through automated carbon, cost, and time assessments. It uses ICE v4.0 and regional datasets (CPWD rates and BIS:7272) to reduce dependency on proprietary databases or cloud connectivity that restricted flexibility for other tools in India (Kurian et al., 2021). By embedding lean set-based design principles and localized environmental metrics directly into the BIM workflow, the prototype supports data-driven decisions during early design stages to minimize waste and embodied carbon emissions.

LITERATURE REVIEW

The growing awareness regarding the environmental impact of buildings has encouraged research on reducing embodied carbon through design and construction decisions (Röck et al., 2023). Retrofitting strategies, such as selective renovation, can achieve 60–90% reductions in embodied emissions relative to demolition and rebuild without analysis, leading to avoidable waste (Bragadin et al., 2023; Lee et al., 2024; Sartori & Hestnes, 2007).

Lean design aims to minimise waste in time, material, cost, and process while maintaining value for the client (Emmitt et al., 2004; Heier et al., 2023; Ko & Chung, 2014). Lean principles encourage automation in Building Information Modelling (Mehdipoor et al., 2025). It has been demonstrated that integrating lean principles into BIM workflows has enhanced coordination and shown sustainable outcomes (Sacks et al., 2010; Wresniwira et al., 2025). Set-based design, a core lean construction, systematically evaluates options enabling comparisons to arrive at the right solution (Castañeda et al., 2023). The adoption of lean construction helps to balance carbon, cost, and time metrics (Pozzer et al., 2025).

While several studies have demonstrated carbon evaluation integration with BIM, existing workflows often require manual export and prioritize new construction over selective retrofitting (Parece et al., 2025). Consequently, design professionals lack tools within the BIM environment to support renovation decision-making (Elagiry et al., 2019), forcing a reliance on external platforms or manual spreadsheet analysis that is tedious, error-prone, time-consuming, and inconsistent with lean principles (El Mounla et al., 2025).

Autodesk Revit's Application Programming Interface (API) provides access to model geometry, parameters, and material data for automation using C# and Python. Specifically, PyRevit serves as an open-source Python-based extension that enables lightweight automation and rapid prototyping, offering potential for developing sustainable design frameworks.

This research addresses the critical gap in integrated decision support tools that combine lean methodologies with multi-criteria assessment within native BIM environments for sustainable renovation projects, as current solutions require manual data transfer between BIM and external databases, creating inefficiencies that hinder timely decision-making during conceptual design.

METHODOLOGY

The development of EcoFix followed a structured, step-by-step approach within the Autodesk Revit environment using PyRevit as the implementation framework. Initially, the requirements of the tool were defined to enable comparative evaluation of renovation strategies—retain, retrofit, demolish, and rebuild—based on embodied carbon, cost, and time. Following this, the development environment was established by configuring PyRevit within Revit to support

Python-based scripting and plugin creation. A custom PyRevit extension was then created, including a dedicated ribbon tab and pushbutton, to integrate the tool into the Revit user interface. A selection mechanism was implemented using the Revit API to allow users to select specific building elements for analysis.

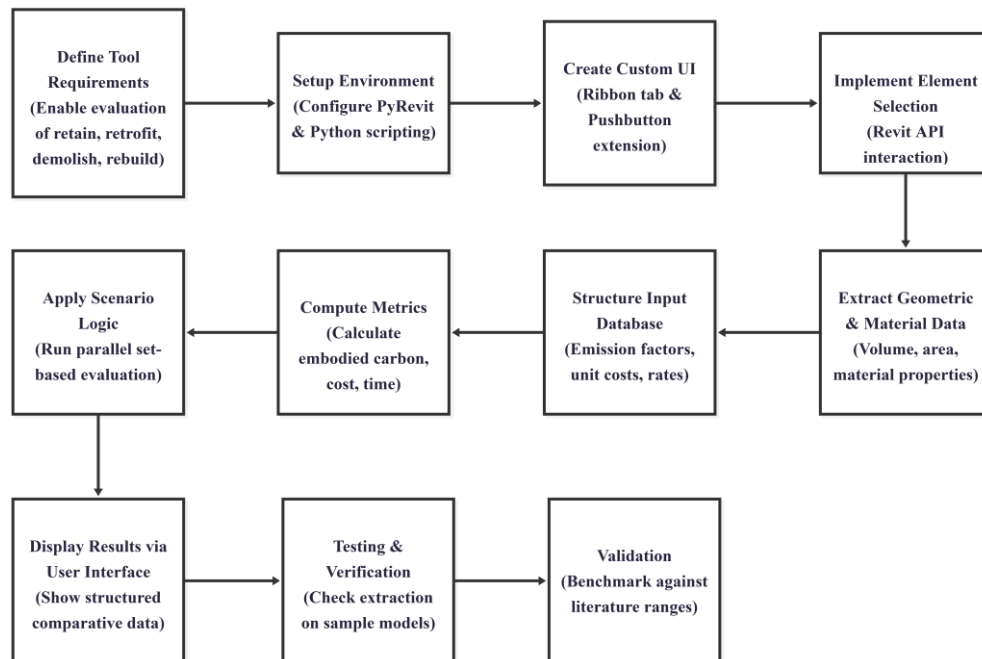


Figure 1: Methodology

Subsequently, scripts were developed to extract geometric and material data from the selected elements, including parameters such as volume, area, and material properties. These extracted values were processed to compute material quantities required for further analysis.

Input parameters such as emission factors, unit costs, and productivity rates were structured as a database and linked through the Python code within the PyRevit environment. During execution, the script dynamically retrieves the relevant parameter values based on the selected element type and multiplies them with the extracted quantities from the Revit model to compute embodied carbon, cost, and time. Scenario-based logic was then implemented to simulate different renovation strategies, namely retain (no intervention), retrofit (partial replacement), demolish (complete removal), and rebuild (full reconstruction). All scenarios were evaluated in parallel following a set-based approach, enabling comparative analysis across carbon, cost, and time parameters.

A user interface was developed within the PyRevit to display the computed results in a structured format, facilitating decision-making directly within the Revit environment. The tool was tested on sample models to verify the accuracy of data extraction and computation. Finally, the outputs were validated by comparing them with benchmark ranges reported in literature, ensuring consistency and reliability of the results.

RESULTS AND DISCUSSIONS

SOFTWARE ENVIRONMENT

Ecofix was developed in Python 3.9 using the PyRevit framework, which provides access to Autodesk Revit API through IronPython scripting. The prototype was tested on Revit 2025. PyRevit allowed the tool to be placed on a customised ribbon tab inside Revit with a pushbutton called Ecofix. When clicked, the script runs in the background, where it allows the user to pick

the element to run the analysis on, gather the element data, perform calculations and return the result through a dialogue-box interface. By using PyRevit, the use of an external database and add-ins were avoided, as PyRevit enabled incorporation of the analysis tool within the modelling environment. In addition, all the calculations were carried out locally. Consequently, the results were generated without any lag or delay.

SYSTEM ARCHITECTURE

The system architecture of EcoFix is divided into five functional layers (conceptual diagram in Figure 2):

1. **User Interaction Layer:** A PyRevit form prompts the user to select an element and choose the analysis mode: Retrofit, Demolish, Retain or Rebuild.
2. **Data Extraction Layer:** The Revit API retrieves each element's name, category, material, area, and volume. Reinforcement quantities were estimated using predefined ratios when reinforcement data is missing.
3. **Database Layer:** Embedded dictionaries store carbon, cost, and time factors for common materials. Values were derived from the Inventory of Carbon and Energy (ICE v4.0), Schedule of Rates and labour productivity factor from BIS: 7272-(part 1):1974 guidelines.
4. **Computation Layer:** The program multiplies extracted quantities by the corresponding factors to determine totals for embodied carbon, cost, and time across scenarios. The demolition path additionally computes salvageable quantity, salvage cost, resale value, reuse-saving, and net demolition cost.
5. **Visualisation Layer:** Results are displayed inside Revit through message dialogues and summary tables, showing both gross and net scenarios (e.g., demolition gross cost vs. demolition net cost after resale, and demolition net carbon lost vs. carbon recovered via reuse/recycling).

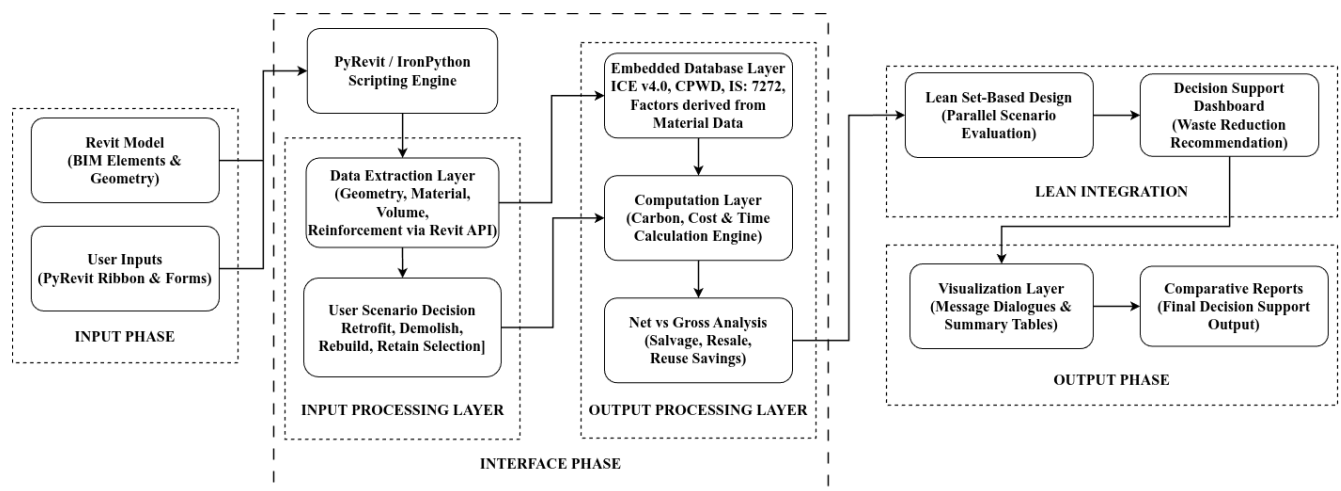


Figure 2: Ecofix system architecture overview

DATA SOURCING AND FACTOR DERIVATION

The prototype uses a predefined internal database for embodied carbon, cost, and time estimation, embedded as lookup tables within the Python script. This eliminates dependency on external databases and enables automatic mapping of factors to Revit-extracted quantities.

Embodied carbon factors were derived from the University of Bath ICE v4.0 database, with values standardized to volumetric units and supplemented with transportation impacts. Cost data were obtained from CPWD Schedule of Rates (2022) and standard rate analysis.

Time estimation factors were based on BIS 7272 (Part 1, 1974) for construction activities, while demolition and retrofit durations were derived using literature-based adjustment factors.

Salvage Factor and Resale Values

To account for material recovery from demolition, the salvage factors are also derived from EPA report. These values allow the prototype to compute the carbon credit resulting from salvaging, recovering, and reusing. The resale values are based on the current market rates.

Table 1: Waste material recycling and landfill proportion (Blay-Armah et al., 2024)

Waste material	Recycle %	Landfill %	Waste material	Recycle %	Landfill %
Aluminium	80	20	Gypsum		100
Brick	50	50	Mineral wool		100
Concrete	90	10	Plaster		100
Paint		100	Plastic		100
Glass	50	50	Steel	92	8
Timber	90	10	Tile		100

WORKFLOW OF ECOFIX

The operational workflow of the prototype within Autodesk Revit environment is shown in Figure 3. The tool has been developed as a PyRevit extension and runs entirely within the Revit environment. The user begins by selecting a project city (such as Bengaluru, Delhi, Mumbai, or Hyderabad) from the startup prompt. Once confirmed, the user has to activate the EcoFix command from the custom Energy Efficiency tab and selected elements to analyse. The prototype processes each selected element in sequence until the user exits the session.

For each element, the system performed the following automated steps:

- **Element and Geometry Extraction:** The prototype retrieves the element name, category, material list, and geometric data (area, volume, and rebar properties) using the Revit API. It then computes the reinforcement weights wherever rebar geometry exists.
- **Material Quantification:** The script attempts detailed volume extraction for each material. If the model lacks material separation, fallback material ratios were applied (e.g., wall = 80% brick, 15% plaster, 5% paint). This ensures that all elements, even schematic ones, could be analysed.
- **Material Classification:** Each material is mapped to a demolition category (e.g., concrete, brick, steel, glass, timber, etc.) for consistent factor lookup.
- **Reuse Decision Handler:** When a door or window is selected, the tool prompts the user to decide if it would be reused. The reuse handler estimates the corresponding cost and carbon savings based on the number of reused units.
- **Scenario Computations:** The user then must choose one of four analysis modes—Retrofit, Demolish, Rebuild, or Retain:
 - i. **Retrofit** applies carbon, cost, and time factors to the quantities based on the retrofit process chosen.
 - ii. **Demolition** computes both gross and net impacts, incorporated salvageable material recovery, resale value, and reuse savings.

- iii. **Rebuild** calculates full new construction quantities and was combined with demolition results.
- iv. **Retain** assumes minimal maintenance and applies the factors associated with repainting.
- **Result Aggregation:** The engine multiplies extracted quantities with their respective carbon, cost, and time coefficients, summing results for all materials. Demolition mode separately computes resale and reuse net-cost scenarios to identify the most beneficial case.
- **Result Display and Report Generation:** The prototype displays a summary dialogue showing total embodied carbon (kgCO₂), cost (₹), and time (days) for each scenario. Confirmed decisions are stored in a session-level report, which are then exported for comparison and record-keeping.

RETROFIT WORKFLOW

In Retrofit mode, the prototype estimates partial refurbishment impacts by applying material carbon factors.

When the user selects an element, the prototype gives the element analysis which consists of volume, area, material used, and asks the user to pick between renovation options, when the user picks the retrofit option, it displays retrofit options available that are relevant to the chosen element type, the system automatically calculates updated carbon, cost, and time using the retrofit coefficients. It then displays the result as shown in the Figure 3.

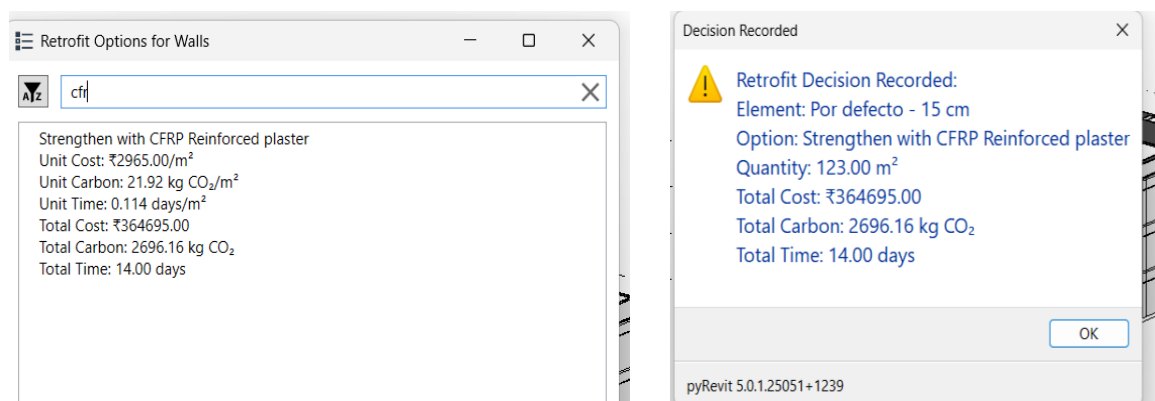


Figure 3: (a) Retrofit option, and (b) retrofit analysis report

$$\text{Total Carbon} = \Sigma(\text{Material quantity} \times \text{Embodied Carbon Factor})$$

$$\text{Transportation} = \text{Material quantity} \times \text{Distance} \times \text{Transport Factor (0.7375)} \quad [17]$$

$$\text{Embodied Carbon} = \text{Material} + \text{Transport} + \text{Installation (Cradle – to Gate[A1 – A5])}$$

The result for embodied carbon obtained by the prototype was 21.92 kgCO₂/m², which is within the limits based on the literature by Mistretta et al. (2019) the cost for CFRP reinforced plaster was ₹2965/m² in accordance with the market rate.

DEMOLITION AND SALVAGE WORKFLOW

The Demolition module of the prototype evaluates both *gross* and *net* environmental and economic impacts.

The system determines the base demolition cost and embodied carbon, then adjusts them by computing salvageable quantity (via salvage fraction), salvage cost, resale value, and reuse saving (if doors/windows are reused). The reports that were generated by the demolition module as shown in Figure 4.

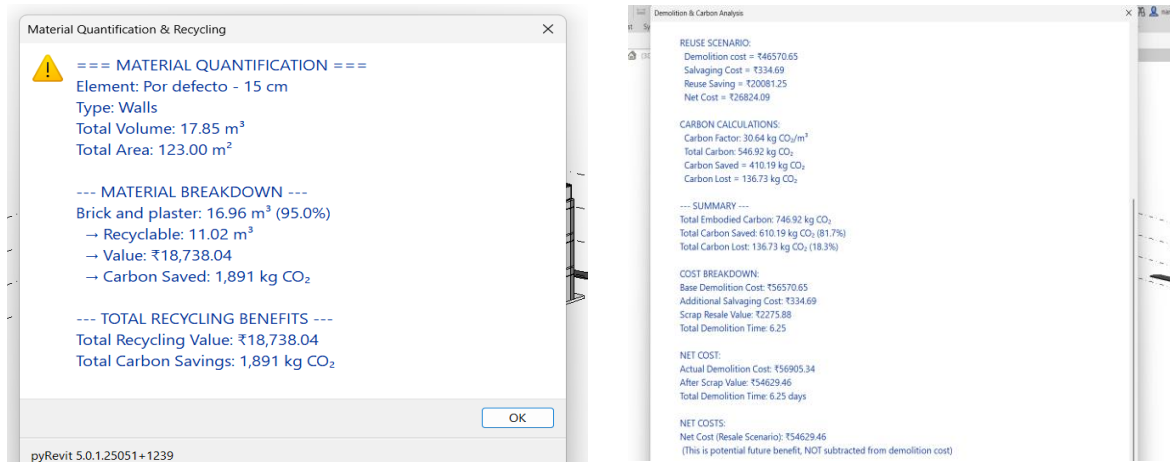


Figure 4: (a) Demolition analysis material quantification, and (b) detailed demolition and carbon analysis

Total demolition emissions

$$E_{demo} = E_{equip} + E_{transport} + E_{proc}$$

Net demolition cost and carbon are then calculated as:

$$Net\ Cost = (Base + Salvaging\ Cost) - (Resale\ Savings)$$

$$Net\ Carbon = C_{gross\ demo} - (C_{salvage} + C_{reuse})$$

When a wall of volume $17.85\ m^3$ was selected, the total demolition carbon obtained was $746.92\ kgCO_2$, of the total 81.7% was recyclable and rate for demolition of a wall is $₹460/m^2$. This is within acceptable limits based on Blay-Armah et al. (2024).

RETAIN WORKFLOW

The Retain mode assumed minimal maintenance interventions; here, we had considered repainting activity alone to be done for the selected element under the retain option since it is a renovation project. The report generated by the retention analysis is as shown in Figure 5.

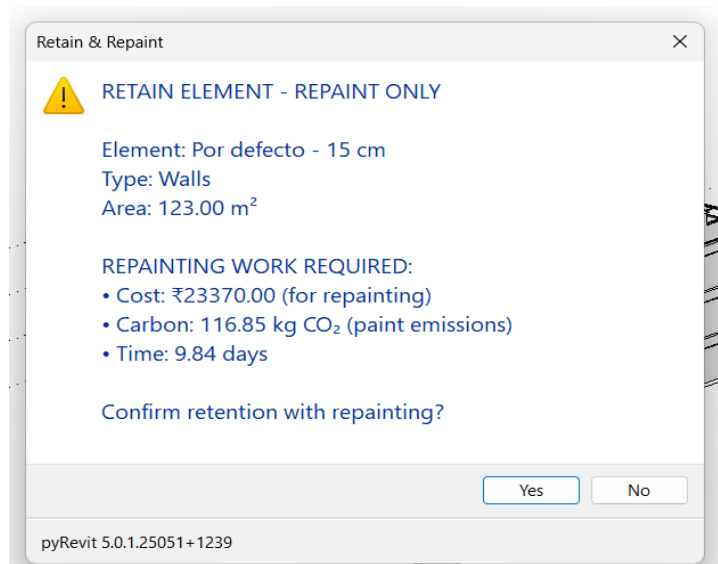


Figure 5: Retain analysis report by Ecofix

Retain Scenario Carbon Calculation

$$C_{retain} = A_{paint} \times EF_{paint}$$

where:

C_{retain} = embodied carbon for repainting under Retain mode (kgCO₂e)

A_{paint} = surface area of the element being repainted (m^2)

EF_{paint} = embodied carbon emission factor of paint ($\text{kgCO}_2\text{e per m}^2$)

The retain scenario considers only repainting activity which is a light retrofit option and the prototype gives the result $0.95 \text{ kgCO}_2/\text{m}^2$, which is acceptable based on the report by Bienert et al. (2023). The cost is in accordance with the market rate is ₹Click or tap here to enter text. $190/\text{m}^2$.

REBUILD WORKFLOW

The Rebuild mode represents complete reconstruction after demolition, combines demolition and new-build results to show the full lifecycle impact. The Rebuild analysis flow and report are as shown in Figure 6a and 6b.

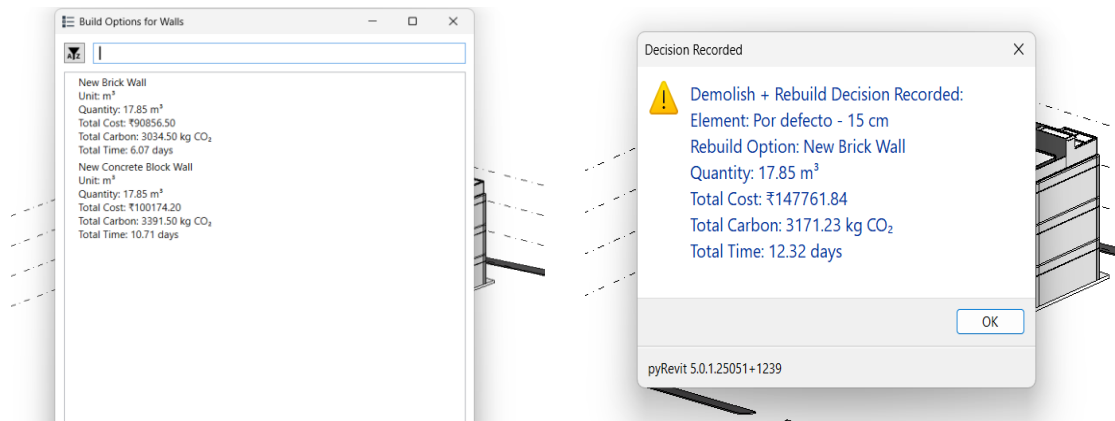


Figure 6: (a) Rebuild options available for the element, and (b) demolition + rebuild report by Ecofix

Rebuild Carbon Calculation

$$C_{\text{rebuild}} = \sum_i (V_i \times EF_i)$$

where:

C_{rebuild} = total embodied carbon from demolition and new construction (kgCO_2e)

V_i = quantity or volume of material i

EF_i = embodied carbon emission factor of material i ($\text{kgCO}_2\text{e /quantity}$)

FINAL REPORT AND COMPARISON REPORT GENERATION

After each element is analysed, EcoFix stores the outputs in a cumulative dataset. When the user finished the session, the tool automatically compiles a Comparison Report, summarising element type and quantity, Carbon, cost, and time comparing retrofit, demolish, and retain scenarios, the recommended action (highlighted based on the lowest combined impact), as shown in Figure 7. Complete comparison between renovation analysis done by the user and Demolition plus Rebuild of the complete structure, as shown in Figure 7. This report provides an aggregated overview across all analysed elements, effectively acting as a decision-support dashboard.

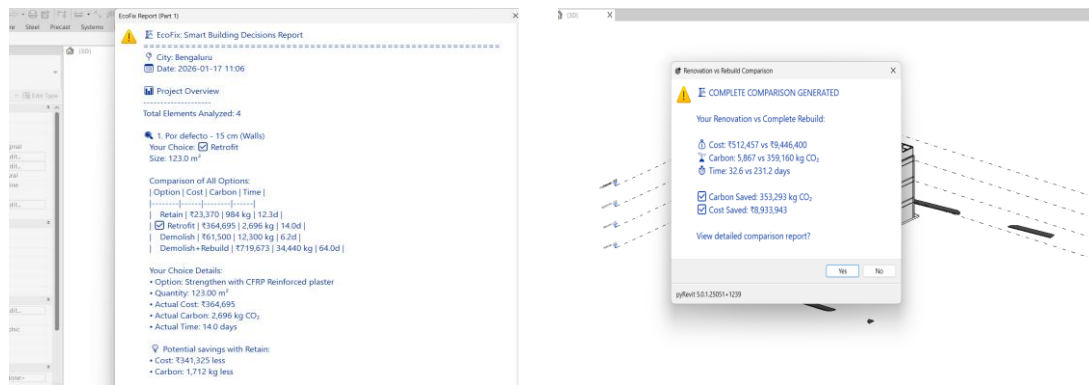


Figure 7: Reports generated by Ecofix after the analysis.

INTEGRATION OF SET-BASED AND LEAN DECISION-MAKING

The prototype supports building renovation decisions by integrating set-based design principles with lean construction methodologies. It addresses the core lean objective of eliminating waste in materials and time information while maintaining multiple suitable alternatives throughout the decision-making process.

Set-Based Design Implementation

The prototype operationalises set-based design through its parallel evaluation architecture, unlike conventional tools requiring early commitment to a single strategy. The system shows simultaneous scenarios for each element: Retrofit, Demolish, Retain, Demolish plus Rebuild. This study could help in analysing different scenarios simultaneously and improving flexibility in the decision-making process, thus saving material, time, and resources.

Lean Decision-Making Workflow

The tool aligns with lean principles through its streamlined workflow that eliminates several forms of construction waste:

- **Material waste reduction:** By quantifying salvageable materials and reuse opportunities, the prototype helps preserve embodied carbon that would otherwise become demolition waste.
- **Process waste elimination:** Manual quantity take-offs and spreadsheet analyses, which typically consume hours per element, are automated, reducing process time from hours to seconds while improving accuracy.
- **Set-based decision making:** By systematically comparing all the alternatives, this tool reveals optimal solutions that might be overlooked in conventional point-based approaches, such as selective demolition with material reuse combined with partial retrofit.

LIMITATIONS:

While the EcoFix tool provides valuable decision support, several limitations should be acknowledged. The tool uses standardized national databases (CPWD, BIS 7272:(1974)) that represent average theoretical values rather than actual site-specific conditions for time and cost factors. With more real-time data the efficiency of the tool could be further validated. The analysis focuses primarily on embodied carbon (A1-A5 stages), excluding operational energy impacts and end-of-life considerations. Additionally, the tool does not perform structural feasibility assessments, assuming all retrofit options are technically viable. As a Revit-based prototype, scalability to entire building portfolios would require enhanced batch processing

capabilities. Future work could address these limitations through site-validated databases, structural integration, and lifecycle assessment enhancements.

CONCLUSION

The EcoFix prototype successfully integrates embodied carbon, cost, and time analysis directly into the BIM workflow using Revit and PyRevit. It would enable designers to assess retrofit, retain, and demolition options within a single framework, eliminating reliance on external software. Results show that retrofit and retain consistently outperform demolition in efficiency, supporting circular economy principles through salvage and reuse factors. Automation reduces manual effort and promotes lean design. Validation confirms the tool's accuracy, with results within $\pm 3\%$ deviation, that could establish it as a reliable tool for early-stage sustainable decision-making.

In conclusion, EcoFix has the potential to transform Revit from a passive modelling environment into an active sustainability decision-support system, aligning with global trends toward circularity, digitalisation, and low-carbon construction. The approach presents a scalable framework for future BIM-based sustainability tools and supports informed decision-making for sustainable renovation practices.

REFERENCES

- Besana, D., & Tirelli, D. (2022). Reuse and Retrofitting Strategies for a Net Zero Carbon Building in Milan: An Analytic Evaluation. *Sustainability*, 14(23), 16115. <https://doi.org/10.3390/su142316115>
- Blay-Armah, A., Bahadori-Jahromi, A., Mylona, A., & Barthorpe, M. (2024). A life cycle assessment of building demolition waste: a comparison study. *Proceedings of the Institution of Civil Engineers - Waste and Resource Management*, 177(3), 100–113. <https://doi.org/10.1680/jwarm.22.00012>
- Bureau of Indian Standards, G. of I. (1974). *IS 7272-1 (1974): Recommendation for Labour Output Constants for Building Work, Part I: North Zone*. Bureau of Indian Standards. <https://law.resource.org/pub/in/bis/S03/is.7272.1.1974.pdf>
- Castañeda, K., Herrera, R. F., Sánchez, O., & Mejía, G. (2023). *Set-Based Design in Construction Projects: Benefits, Difficulties and Trends*. 1092–1103. <https://doi.org/10.24928/2023/0197>
- Central Public Works Department (CPWD), G. of I. (2022). *Delhi Schedule of Rates (DSR) 2022*. https://cpwd.gov.in/Publication/DSR_2022.pdf
- El Mounla, K., Beladjine, D., & Beddiar, K. (2025). Integrating BIM with Lean Principles for Enhanced Decision-making: Optimizing Insulation Material Selection in Sustainable Construction Project. *Energy Informatics*, 8(1), 61. <https://doi.org/10.1186/s42162-025-00518-4>
- Elagiry, M., Marino, V., Lasarte, N., Elguezabal, P., & Messervey, T. (2019). BIM4Ren: Barriers to BIM Implementation in Renovation Processes in the Italian Market. *Buildings*, 9(9), 200. <https://doi.org/10.3390/buildings9090200>
- Emmitt, S., Sander, D., & Christoffersen, A. K. (2004). IMPLEMENTING VALUE THROUGH LEAN DESIGN MANAGEMENT. *12th Annual Conference of the International Group for Lean Construction*.
- Heier, N., Chakravarti, A., Røyne, A., & Parrish, K. (2023). *Exploring How Lean Project Delivery Supports Carbon Capture, Utilization, and Storage for Industrial Retrofits*. 531–539. <https://doi.org/10.24928/2023/0238>
- Jørgensen, M. B., Kristoffersen, A. E., & Kamari, A. (2025). Evaluating the Environmental Impact of Building Renovation Depth: A Danish Perspective. *Sustainability*, 17(24). <https://doi.org/10.3390/su172411107>

- Khaddaj, M., & Srour, I. (2016). Using BIM to Retrofit Existing Buildings. *Procedia Engineering*, 145, 1526–1533. <https://doi.org/10.1016/j.proeng.2016.04.192>
- Ko, C.-H., & Chung, N.-F. (2014). Making Design Process Lean Design Management. *22nd Annual Conference of the International Group for Lean Constructio*.
- Kurian, R., Kulkarni, K. S., Ramani, P. V., Meena, C. S., Kumar, A., & Cozzolino, R. (2021). Estimation of Carbon Footprint of Residential Building in Warm Humid Climate of India through BIM. *Energies*, 14(14), 4237. <https://doi.org/10.3390/en14144237>
- Mehdipoor, A., Hajiagha, A. R., Mehdipoorkaloorazi, S., & Iordanova, I. (2025). *A Lean Approach to Productivity Improvement in Roof Panel Manufacturing for Modular Off-site Construction Using DfMA and Emerging Technologies*. 787–798. <https://doi.org/10.24928/2025/0189>
- Parece, S., Resende, R., & Rato, V. (2025). BIM-based life cycle assessment: A systematic review on automation and decision-making during design. *Building and Environment*, 282, 113248. <https://doi.org/10.1016/j.buildenv.2025.113248>
- Pozzer, A. E., Rausch, C., & Leite, F. (2025). *Exploring the Role of Lean Construction in Decarbonizing the Building Industry: Insights From Industry Experts*. 1137–1148. <https://doi.org/10.24928/2025/0173>
- Röck, M., Balouktsi, M., & Ruschi Mendes Saade, M. (2023). Embodied carbon emissions of buildings and how to tame them. *One Earth*, 6(11), 1458–1464. <https://doi.org/10.1016/j.oneear.2023.10.018>
- Sacks, R., Koskela, L., Dave, B. A., & Owen, R. (2010). Interaction of Lean and Building Information Modeling in Construction. *Journal of Construction Engineering and Management*, 136(9), 968–980. [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0000203](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000203)
- World Green Building Council. (2019). *New report: The building and construction sector can reach net zero carbon emissions by 2050*. World Green Building Council. <https://worldgbc.org/article/new-report-the-building-and-construction-sector-can-reach-net-zero-carbon-emissions-by-2050/>
- Wresniwira, S., Adha, N., Hazel, F., Hernadi, A. D., Naufal, A. L., Widyastuti, A. R., Sentosa, G. A., Mardiansyah, B., Saputra, R. A., & Fajarwanto, A. (2025). *Lean Philosophy's Respect for People: a Key Driver of High-performance Projects on Large-scale Construction in Indonesia*. 59–69. <https://doi.org/10.24928/2025/0243>