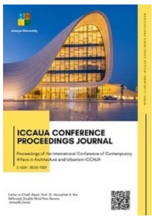

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Adaptive Reuse vs. New Construction: Sustainable Transformation of a Transit Hostel at IIT Kharagpur

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Abstract

With the increasing demand for built spaces, it is essential for us to be mindful about its environmental impact and hence aim to minimize new construction. This paper investigates the adaptive reuse of a transit hostel at Indian Institute of Technology (IIT), Kharagpur (est. 1951) into a wellness and counselling centre for students, juxtaposed against the option of new construction. The research is guided by critical parameters, including heritage value, cost efficiency, environmental impact, and functional adaptability. A comparative cost-benefit analysis, using the above-mentioned parameters, serves as the central methodological framework, incorporating both qualitative and quantitative evaluation. Furthermore, repurposing the transit hostel preserves its heritage value while accommodating the necessary transformations for a modern counselling facility. This research contributes to the discourse on sustainable campus planning by showing the differences between new construction and adaptive reuse. It offers a replicable framework for similar initiatives, bridging heritage conservation with contemporary needs..

Keywords: Adaptive Reuse; Cost-Benefit Analysis; Built heritage, Conservation, Environmental Impact.

1. Introduction

1.1 Background

The concept of adaptive reuse has gained prominence in contemporary architecture and urban planning as a sustainable approach to reimagining existing structures. It emphasizes the transformation of underutilized or outdated buildings into functional spaces that meet current needs while preserving their historical, cultural, and architectural significance. Adaptive reuse not only conserves natural and built resources but also minimizes urban waste, promotes heritage conservation, and contributes to environmental sustainability.
The Transit Guest House at IIT Kharagpur, located opposite the B.C. Roy Hospital, is an aging structure with significant potential for adaptive reuse. Originally designed as the hospital building which was later reused as the guest house for drivers, the building has become underutilized over time due to its outdated design and limited functionality. Its strategic location within the campus and proximity to critical facilities makes it an ideal candidate for transformation. The adaptive reuse of the Transit Guest House not only meets this pressing need but also ensures the preservation of its architectural character, aligning with the principles of sustainability and cultural heritage.

1.2 Need of the Study

This study intended to investigate, through an actual case, the veracity of various types of benefits commonly associated with adaptive reuse, which may be articulated as follows.

Environmental sustainability

Think of adaptive reuse as giving a sound old building a second life, instead of sending it to the landfill. When we keep most of the original walls, floors, and foundations, we sidestep the enormous amounts of concrete, steel, and glass a new building would demand—and those materials are some of the biggest carbon culprits in construction. Just as important, we avoid the mountain of debris that demolition creates. Fewer truckloads of rubble headed to a dump means cleaner air, less dust, and a smaller environmental footprint from start to finish.

Economic benefits
Money matters, and reuse projects almost always come out ahead. A structure's bones—the columns, beams, foundation, and utility hookups—are already paid for, so the budget can focus on smart upgrades rather than expensive groundwork. Because you're buying fewer raw materials, you're also less exposed to price swings in commodities like steel or cement. Permits and approvals tend to be quicker, too, which gets tenants or businesses back inside faster and begins generating revenue sooner—a win for both owners and investors.

Cultural and heritage conservation
Buildings aren't just bricks; they're storytellers. Keeping a historic façade or an old timber roof truss preserves the craftsmanship and character that make a place unique. Residents and visitors alike can trace a neighbourhood's evolution through its architecture, giving them a stronger sense of belonging. This continuity of memory often attracts cultural tourism and boosts local pride—people genuinely enjoy seeing their city's past woven into its present.

Urban revitalization
Finally, re-energizing an empty mill or warehouse can jump-start an entire district. Instead of pushing development to the fringes, adaptive reuse pulls life back into established streets, making better use of existing transit lines, sidewalks, and utilities. New cafés, studios, or housing inside an old shell bring foot traffic at all hours, improving safety and economic vibrancy. It's a practical recipe for denser, more liveable cities—one that breathes fresh energy into forgotten corners without spreading the urban footprint any further.

Rising Construction in the World
The global construction industry is witnessing remarkable growth, fuelled by factors such as rapid urbanization, population expansion, economic progress, and advancements in technology. This surge is transforming cities, infrastructure, and the built environment to meet changing societal demands and challenges. The market is expected to grow at a CAGR of 5.3% by 2028. The construction industry is responsible for 37% of total global emissions and that number is not going down, anytime soon. Adaptive reuse can meet at least some of the rising space requirement without adding to the quantum of new construction.

1.3 Aim of the Study
The aim of this study is to develop a framework to compare between adaptive re-use & new construction by analyzing the case of the Transit Hostel at IIT, Kharagpur through the lens of sustainability.

1.4 Objectives of the Study
1. To analyze the heritage value and historical significance of the transit hostel within the IIT Kharagpur campus and assess how adaptive reuse preserves these values.
2. To conduct a comparative cost-benefit analysis of adaptive reuse versus new construction.
3. To evaluate the environmental impacts of both approaches.

1.5 Methodology

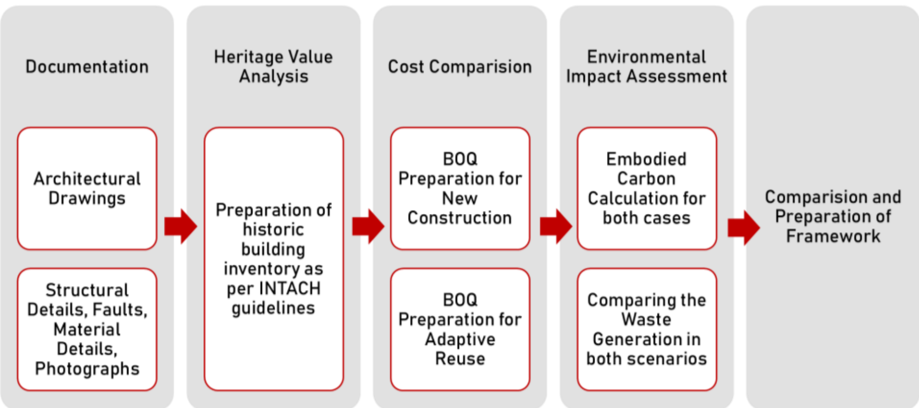

Figure 1. Methodology of the study (Source: Author).

2. Literature Review
2.1 Embodied Carbon Emission Calculation
The embodied carbon analysis was conducted using a system-based approach, comparing the major building elements (walls, floors, fenestration, structural components) between new construction and adaptive reuse scenarios.
It was calculated using a formula –
Embodied Carbon (in kg CO_2 e) = Quantity (mass or volume) x Emission Factor (HM Treasury & Evaluation Task Force, 2020)
The emission factor for different materials in India is given by the "India Construction Materials Database of Embodied Energy and Global Warming Potential" by International Finance Corporation in collaboration with European Union.

The quantities for different building systems were calculated from the documentation and then the embodied carbon of the used materials was calculated for each building system across 2 cases.

2.2 Sustainability and Environmental Impact

Adaptive reuse is widely regarded as a sustainable development strategy. It extends the life of buildings, conserves embodied energy, and reduces both construction waste and carbon emissions. Bullen and Love (2010) and subsequent reviews confirm that the built environment accounts for up to 40% of global energy use and one-third of greenhouse gas emissions. Demolition alone can generate up to 48% of a building's lifecycle solid waste(Armstrong et al., 2023).
Key environmental benefits:

- **Reduction in Embodied Carbon:** By reusing existing structures, adaptive reuse significantly reduces the demand for new materials and associated emissions.
- **Circular Economy Alignment:** Adaptive reuse supports circular economy principles by keeping resources in use and minimizing waste(Othman & Elsaay, 2018).
- **Operational Efficiency:** Retrofitting with energy-efficient systems further reduces operational carbon footprint(Othman & Elsaay, 2018).

2.3 INTACH Guidelines

The re-use of historic buildings and neighborhoods is economically sensible. It is an effective strategy to conserve architectural heritage, particularly by using traditional craftspeople in the process. Such re-use distinguishes between preservation as an ideal on the one hand and, on the other, the goal to prolong the useful life of architectural heritage by retaining as much (and not necessarily, all) of the surviving evidence as a vestigial presence.(Indian National Trust for Art and Cultural Heritage [INTACH], 2024)

2.3.1 Policies by INTACH for Adaptive Reuse

- Priority must be accorded to retaining the continuity of original functions. Any new use must be introduced only after studying its effect on the local context, and must conform to the carrying capacity and vulnerability of the architectural heritage.
- All changes to the original fabric should be preceded and followed by comprehensive documentation. Additions and alterations must respect the coherence of the whole, and must, to the extent possible, engage traditional materials, skills and knowledge in the process.
- When it becomes necessary to modernize and comprehensively alter the original internal functional characteristics of the building or site, its external image must be retained.
- At the outset, the local community must be made aware of the changes envisaged and explained the benefits to be derived(Indian National Trust for Art and Cultural Heritage [INTACH], 2024).

2.3.2 Categories given by INTACH for Reuse & Restoration of structures

The recommendation for Adaptive Reuse is made only for structures which are not listed as Grade-1 heritage. The specific recommendations for the various relevant Grades are as follows. This also aligns with the recommendations of Model Heritage Regulations by TCPO, Govt. of India.

Grade 2A
Intelligent conservation
Internal changes and adaptive re-use may be allowed, subject to strict scrutiny. Care should be taken to ensure the conservation of all attributes for which it is included in Heritage Grade 2A (including its use, if it contributes to heritage significance).
Extension or additional building on the same plot or compound may, in certain circumstances, be allowed, provided that the extension/ additional building is in harmony with the existing heritage building/(s) or precincts especially in terms of façade, and provided that the height, mass, and scale of the extension/ additional building does not hamper the heritage significance of the original building, and it does not obstruct the principal views to and from the heritage building, nor hampers its relationship with the site and setting (if it contributes to heritage significance).

Grade 2B
Intelligent conservation
In addition to the scope for Grade 2A, as above, vertical extension may, in certain circumstances, be allowed, provided that the extension is allowable considering the structural stability of the original building, and provided that such extension is in harmony with the existing heritage building/(s) or precincts especially in terms of façade, and the height, mass, and scale of extension does not hamper the heritage significance of the original building.

Grade 3
Intelligent conservation of attributes/ special features contributing to significance
Internal and external changes and adaptive re-use may by and large be allowed, ensuring that such changes are in harmony and do not hamper the heritage significance of the original building/ special features contributing to its value. Changes may include horizontal and vertical extensions and additional buildings on the same plot or compound.

3. Documentation

3.1 Original Purpose:

The building that now houses the Transit Guest House's construction date is not known but it is from pre-independence colonial era and the purpose at that time is not known now.

3.2 Post-Independence:

After independence, the building was temporarily repurposed to establish the Hospital at IIT Kharagpur.
After the construction of the new hospital in front of it, the building was repurposed as the storage area for the hospital and now it is being used as the Transit Guest House in IIT, a guest house for the drivers that are inside the campus (such as; hospital ambulance driver etc.) and those who come from outside the campus.

3.3 Architectural Value:

The museum has many architectural elements that have been/can be preserved including large arches on the façade, the pitched roof and the intricate details around the windows, the wooden casement windows and metal grills. The architecture from pre-independence era reflects the resilience of the structure.

Figure 2. Site Photograph (Source: Author).

3.4 Construction Details

It is a **load bearing structure** with thick brick walls. The slab is concrete & part of the roof uses timber members with clay tiles as covering.
The **fenestration frame** is **wooden** and covered with wood panels.
As it is a load bearing structure the **foundation** must be a type of **strip footing** which supports the thick walls for stability. The structure is **dilapidated** and there are many visible damages to it.

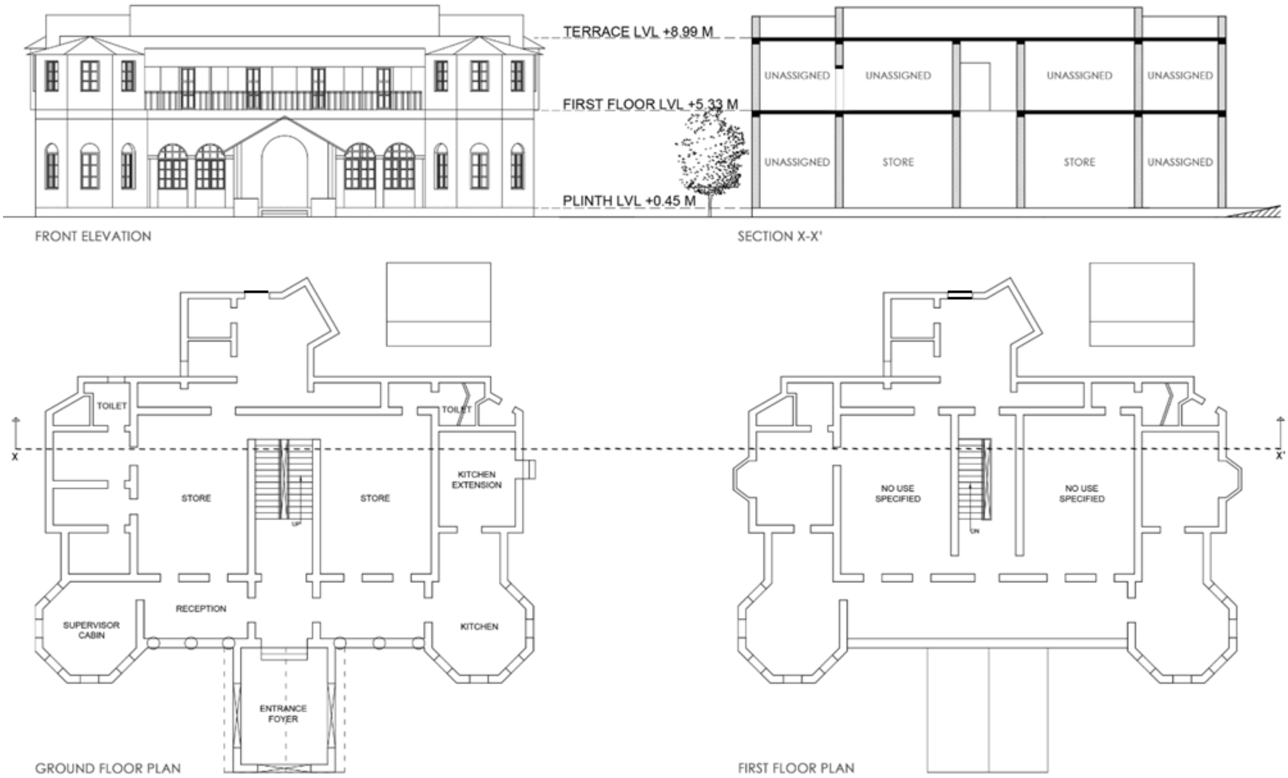

Figure 3. Architectural Drawings - Elevation, Section & Plans (Source: Author).

3.5 Building Inventory (following INTACH guidelines)

Location: In-front of B.C. Roy Hospital, Behind Bachelor's Flats – 3, IIT Kharagpur, West Bengal (W.B.) 721302
Property Type: Building
Past Use: Hospital (1960 – 1965), Storage (1965 – 2000)
Present Use: Transit Hostel (2000 – Present)
Date Established: 20th Century (Before Indian Independence)
Condition: Showing Signs of Deterioration
Ownership: Public (IIT Kharagpur)
Domains of Significance: History ★ ☆ ☆
Socio-Cultural ★ ★ ☆
Aesthetic ★ ★ ☆
Environmental ☆ ☆ ☆
Proposed Grade: 2A
Recommendation: Intelligent Conservation

Figure 4. Site Location (Source: Google Earth).

4. Comparative Analysis

4.1 Cost Benefit Analysis

The cost is calculated for a G+1 Structure with a total B.U.A. = 510 sq.m. for 2 case scenarios. Case 1 is New Construction and Case 2 is Re-use & Repair for equal usable area of 510 sq.m.. Both of these BOQs were prepared using Delhi Standard Rates, 2021. Central Public Works Department, Delhi. Analysis of Rates 2021 is a comprehensive and useful document forming basis for the rates of various items of DSR 2021.

S.No	Description	Unit	Quantity	Shuttering	Rate (INR)	Amount (INR)	CODE (DSR 2021)
1	Earthwork excavation for foundation	cum	141		523.5	73813.5	2.9
2	PCC 1:4:8 in foundation	cum	15	307	6633.05	99495.75	4.1.8 & 4.3.1
3	RCC M20 for columns (with shuttering & reinforcement)	cum	25	804	10078.6	251965	5.1.2, 5.2.2 & 5.9.6
4	RCC M20 for beams (with shuttering & reinforcement)	cum	30	699.45	11418.5	342555	5.3 & 5.9.21
5	RCC M20 for slabs (with shuttering & reinforcement)	cum	35	766.45	11485.5	401992.5	5.9.3
6	Brickwork in cement mortar 1:6 (230mm external walls)	cum	100		6315.4	631540	6.1.1 & 6.2.1
7	Brickwork in cement mortar 1:6 (115mm internal walls)	cum	110		5748.8	632368	6.1.1 & 6.2.1
8	12mm cement plaster 1:6 on walls (internal & external)	sqm	1245		294.85	367088.25	13.1.1
9	Flooring with vitrified tiles + Laying	sqm	510		2097.85	1069903.5	11.49.2 & 8621
10	Painting with acrylic emulsion (2 coats)	sqm	1245		137.86	171635.7	13.60.1
11	Internal electrification (points, wiring, MCBs)	LS	1		150000	150000	
12	Internal plumbing and sanitary installations	LS	1		200000	200000	
13	Labour charges (approx. 25% of item total excluding LS)	LS	1		1010589	1010589	
	Total Estimated Cost					5402946.2	

Table 1. BOQ for New Construction (Source: Author).

Table 2. BOQ for Adaptive Reuse (Source: Author).

S.No	Description	Unit	Quantity	Rate (INR)	Amount (INR)	CODE (DSR 2021)
1	Raking out joints and filling cracks in masonry walls with cement mortar 1:4	sqm	745	462.3	344413.5	14.1.1
2	Injection grouting in cracked masonry (non-structural)	kg	124	793	98332	26.35.3
3	Repairing floor cracks with epoxy/cementitious compound	sqm	245	243.7	59706.5	Sub A/R-2
4	Removal of vegetation growth from walls and roof with root treatment	sqm	320	174.84	55948.8	24.3
5	12mm cement plaster 1:6 on repaired walls	sqm	1245	294.85	367088.25	13.1.1
6	White washing/painting over repaired areas (2 coats)	sqm	1245	137.86	171635.7	13.60.1
7	Scaffolding and surface preparation for all external works	sqm	510	285	145350	14.72
8	Labour charges for repair (approx. 25% of repair items)	LS	1	60000	310618	
	Total Estimated Cost				1553092.75	

New Construction (Case 1)

- **Scope**: G+1 structure, 510 sq.m. built-up area.
- **Total Estimated Cost**: ₹5,402,946.20 (INR)

Adaptive Reuse & Repair (Case 2)

- **Scope**: Comprehensive repair and retrofit of existing structure with 510 sq.m. built-up area.
- **Total Estimated Cost**: ₹1,553,092.75 (INR)

Looking at these BOQs we can conclude that there is a **71.25%** reduction in the total cost of the structure if we opt for Adaptive Re-Use instead of New Construction.

4.2 Environmental Impact Analysis

Embodied Carbon Calculation

Embodied carbon refers to the total carbon dioxide (CO_2) emissions generated during the lifecycle of building materials — from raw material extraction to manufacturing, transportation, installation, and eventual disposal. In the context of architectural sustainability, especially for adaptive reuse projects, minimizing embodied carbon is a critical measure of environmental performance.

Baseline vs Proposed Scenarios

The following data outlines a comparative analysis of **baseline (New Construction)** and **proposed (Reuse and Retrofit)** scenarios. The embodied carbon is calculated across various components — **walls, floor, fenestration, and structural systems** — with emissions reported in kilograms of CO_2 equivalent (kg CO_2e). There are 3 parts of carbon emission – Material, Transport 1 & Transport 2. Transport 1 & 2 refers to the transport of said material from the source to a distributer and from distributer to site, respectively.

Table 3. Baseline vs Proposed CO2 equivalent emission (Source: Author).

System Type	Baseline				Proposed			
	Material emissions (kg -CO_2 e)	Transport 1 (kg -CO_2 e)	Transport 2 (kg -CO_2 e)	Total (kg -CO_2 e)	Material emissions (kg -CO_2 e)	Transport 1 (kg -CO_2 e)	Transport 2 (kg -CO_2 e)	Total (kg -CO_2 e)
Wall	215.6	0.0	0.0	215.6	92.7	0.0	0.0	92.7
Roof	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Floor	18.3	0.0	0.0	18.3	7.4	0.0	0.0	7.4
Fenestration	84.4	1.3	0.3	85.9	57.4	0.0	0.0	57.4
Structural	83.7	0.2	0.2	84.1	25.5	0.0	0.0	25.5
		Grand Total emissions per functional unit (kg -CO_2 e)		403.9		Grand Total emissions per functional unit (kg -CO_2 e)		182.9

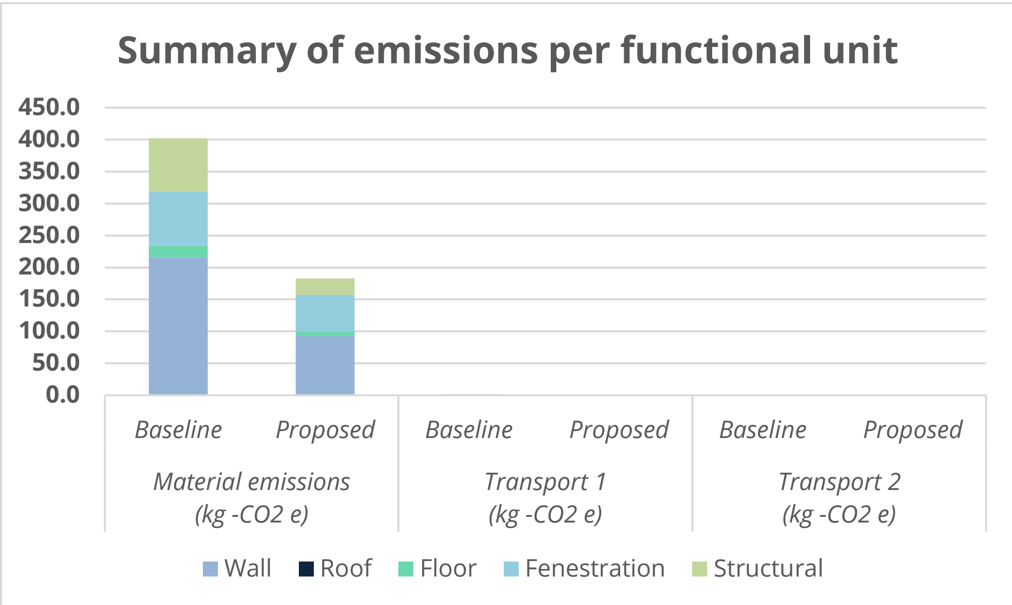

Figure 5. Summary of Emissions (Source: Author).

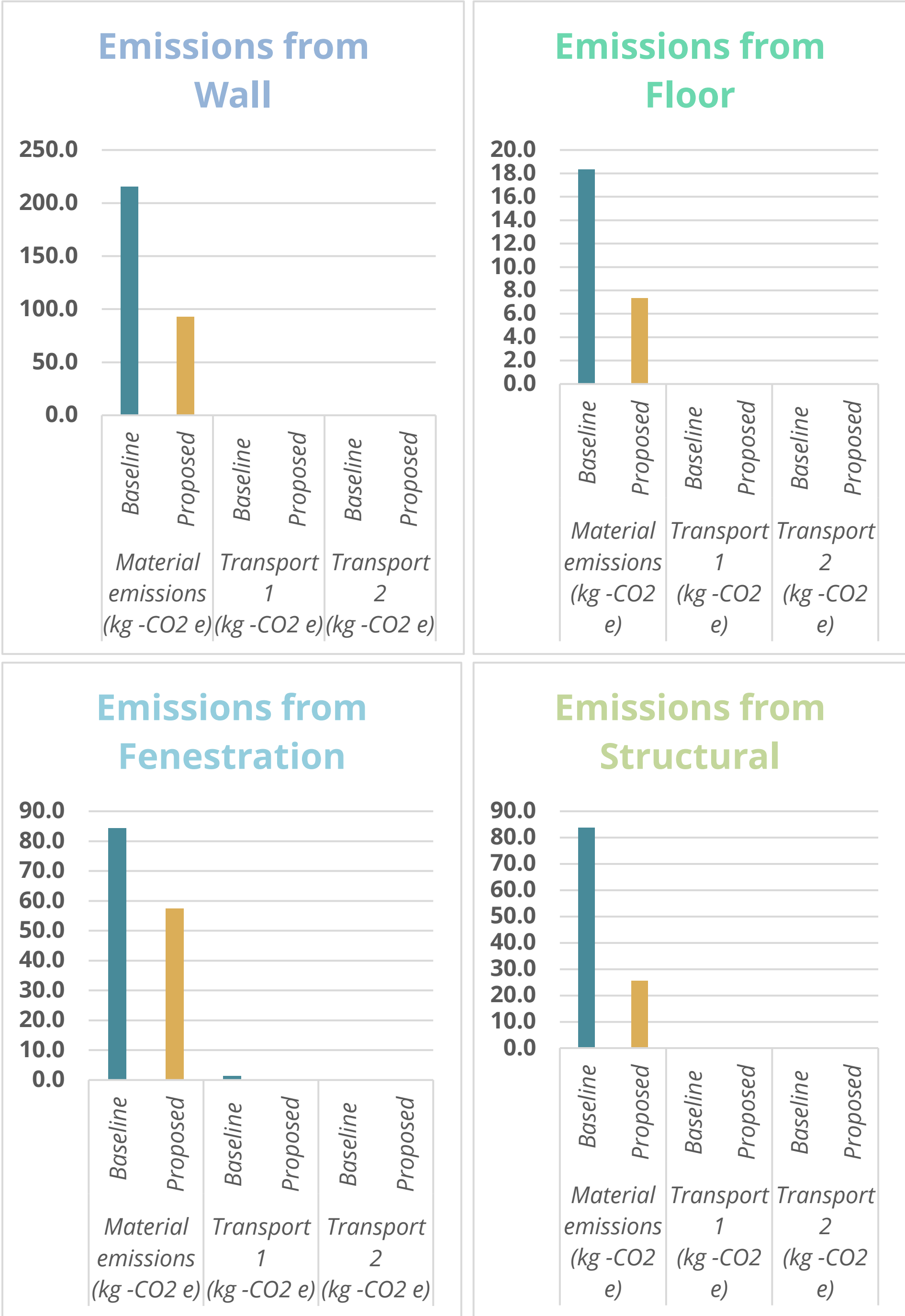

Figure 6. Emissions from different building systems (Source: Author).

These findings underscore the value of adaptive reuse in reducing embodied carbon. By retaining existing structural systems and reusing materials, the project **reduces 54.71%** emissions that would otherwise result from new construction. The strategy is particularly effective in areas like structural frames and masonry walls — components with high material mass and carbon intensity. This is without the consideration of kg CO_2 e emissions from Demolition.

5. Conclusion & Framework

The Transit Hostel case at IIT Kharagpur demonstrates that adaptive re-use can deliver substantial sustainability dividends without sacrificing functionality or heritage value. By retaining the existing structure while repairing incurred damages, the project avoids **54.7 %** of the embodied-carbon emissions that a comparable new build would generate and cuts total project cost by **71.25 %**—even before accounting for demolition waste and time savings. Beyond the quantified gains, the scheme preserves a pre-independence landmark, reinforces campus identity, and aligns with INTACH guidelines that prioritize continuity of use and community engagement. Collectively, the findings confirm that, when structural integrity is recoverable and cultural significance is high, adaptive re-use is the environmentally, economically, and socially superior pathway.

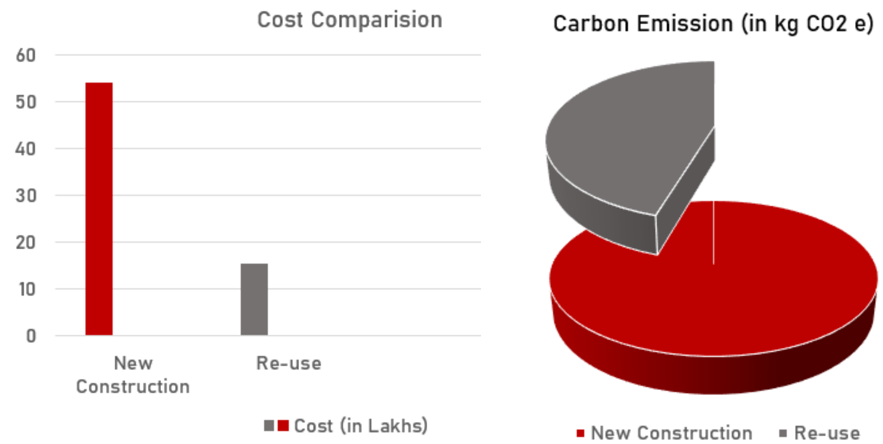

Figure 7. Comparative Analysis Summary (Source: Author). **Figure 8**. Heritage Value (Source: Clipartmax).

Based on this understanding, the proposed framework is recommended for taking a decision on adaptive reuse of historic structures.

Table 4. Framework for choosing between Adaptive Reuse vs New Construction (Source: Author).

Step	Key Questions & Actions	Outputs / Decision Gates
1. Context & Heritage Screening	• Is the building protected or culturally significant? • Does it contribute to local identity or streetscape? • Rapid desktop review of listings, heritage inventories, and community sentiment.	**Go/No-go 1:** If heritage value is negligible *and* policy allows demolition, proceed to Step 2 with both options open; otherwise, give adaptive re-use priority.
2. Structural & Technical Audit	• Commission visual survey, material testing, and structural modelling. • Identify load-bearing capacity, envelope condition, moisture ingress, hazardous materials.	**Go/No-go 2:** If structure is irreparable or fails safety codes even after strengthening, favour new construction; else continue.
3. Functional Fit Analysis	• Map existing spatial layout against future space standards and building-services needs (e.g., HVAC, vertical circulation, accessibility). • Assess flexibility for retrofit interventions.	**Adaptability Index:** Score building on capacity to accommodate new functions with reasonable alterations.
4. Sustainability & Carbon Assessment	• Calculate baseline embodied carbon and operational-energy demands for both scenarios (reuse vs new). • Factor in demolition emissions and material sourcing.	**Green Light Threshold:** Prefer option with significantly lower life-cycle carbon and resource use.
5. Economic Cost-Benefit Analysis	• Prepare BOQs for repair/retrofit and for new build. • Include incentives (heritage grants, tax credits) and social-value monetisation (job retention, tourism).	**Financial Feasibility Gate:** Select the option with the higher Net Present Value (NPV) or shorter payback while meeting performance criteria.
6. Stakeholder & Community Alignment	• Conduct consultations with users, neighbours, planning authorities, and heritage bodies. • Gauge acceptance, potential opposition, and intangible benefits.	**Social License Gate:** Proceed only if preferred option secures clear stakeholder support or manageable mitigation strategies.

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Conflict of Interests
The Author(s) declare(s) that there is no conflict of interest.

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