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BIM-Based Life Cycle Assessment of a G+3 Building in Reinforced Cement Concrete and Ferrocement

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ABSTRACT :

Buildings account for a large share of material use and greenhouse-gas emissions, and the structural frame is one of their most material-intensive parts. Ferrocement, a thin cement mortar reinforced with closely spaced wire mesh, is often suggested as a lighter alternative to reinforced cement concrete (RCC), but its whole-building environmental performance has rarely been examined with BIM-based tools. This study compares RCC and ferrocement versions of a G+3 building through a BIM-based life cycle assessment (LCA). The models and material quantities came from Autodesk Revit, the quantities were assessed in One Click LCA using the Level(s) framework with an EN 15804+A1 basis, and the planned construction sequence of the structural frame was visualised in Autodesk Navisworks TimeLiner. The TimeLiner step is for visualisation only and is not an input to the carbon calculation. The assessed modules were A1–A3, A4, A5, C2, C3 and C4; use-stage impacts and operational energy were excluded. The total global warming potential (GWP) was 3,107 t CO_2e for the ferrocement model and 3,215 t CO_2e for the RCC model, a difference of about 108 t CO_2e (3.4% lower for ferrocement). The product stage (A1–A3) contributed about 95% of emissions in both models, and steel was the largest source. The structural frame, however, contributed almost the same amount in both models (about 213 t CO_2e, derived by subtraction), so the difference between the totals comes from the architectural portion and does not show that the ferrocement frame has lower embodied carbon. The main limitations are unconfirmed equivalence of the architectural quantities, undocumented member sizes and material grades, uncertain dataset mapping for ferrocement, no verified structural-capacity equivalence and a missing gross floor area. The study offers a documented BIM–LCA workflow and a set of data-quality checks, not a conclusive ranking of the two materials.

Keywords— ferrocement; reinforced cement concrete; building information modelling; life cycle assessment; embodied carbon; 4D BIM

1. INTRODUCTION

Buildings account for a large share of global resource use, energy demand and greenhouse-gas emissions. The impacts come from every stage of a building's life, from extracting and processing materials to transport, construction, use, maintenance and demolition. As buildings become more energy efficient in operation, the carbon already locked into their materials gains importance, and the structural frame, usually the heaviest part of a building, deserves particular attention [1], [2]. This is especially relevant in India and similar fast-urbanising regions, where much of the building stock needed in the coming decades has yet to be built.

In Indian practice, reinforced cement concrete (RCC) is the default choice for framed buildings. It is readily available, easy to form, fire resistant and backed by well-established design procedures. Its carbon cost is also substantial: cement manufacture emits large amounts of CO_2, reinforcing steel is energy intensive, and conventional solid sections use large volumes of material. Ferrocement takes a different approach. It uses a cement–sand mortar reinforced with several closely spaced layers of continuous wire mesh, which allows thin, light sections with good crack control, and the mortar can be modified with supplementary cementitious materials or recycled fibres [3]–[5]. Thin sections do not guarantee a lower footprint, however. The mortar contains more cement per unit volume than ordinary concrete, and the wire mesh carries a high embodied carbon per kilogram of steel. Whether ferrocement actually lowers the impact of a complete structure therefore has to be checked by calculation.

Building Information Modelling (BIM) stores a building as a set of objects, each with geometry and material information. Quantities taken from such a model can be traced back to individual elements and then multiplied by emission factors. Life Cycle Assessment (LCA), whose principles and requirements are set out in ISO 14040 and ISO 14044 [6], [7] and applied to buildings through EN 15978 and EN 15804 [8], [9], evaluates environmental impacts in four phases: goal and scope definition, inventory analysis, impact assessment and interpretation. Linking the two avoids re-typing quantities by hand, lets designers compare options while changes are still cheap, and allows the assessment to be repeated quickly when the design changes [2], [10]. The approach has known weak points, namely incomplete material data in models, difficulty in matching model materials to environmental datasets, inconsistent system boundaries and limited automation [11]–[13].

A comparison between RCC and ferrocement is only fair if both options describe the same building, serve the same function and are assessed with the same rules, datasets and boundaries. Otherwise the result may reflect modelling choices rather than the materials. **Research problem:** the authors did not find, in the literature they reviewed, a like-for-like BIM-based comparison of the life-cycle impacts of a ferrocement building structure and its RCC counterpart. **Research question:** how do the embodied carbon and the other indicators available from One Click LCA compare for RCC and ferrocement versions of the same building? **Aim:** to compare the embodied carbon of RCC and ferrocement versions of a G+3 building using Autodesk Revit models and One Click LCA, and to judge the potential of ferrocement as a sustainable alternative. **Objectives:** (i) to build RCC and ferrocement BIM models;

(ii) to define the materials and extract quantities; (iii) to carry out the LCA; (iv) to compare embodied carbon and the other available indicators; (v) to identify the main contributing materials and building elements; and (vi) to assess the potential of ferrocement from the results.
This paper contributes a documented BIM–LCA workflow applied to RCC and ferrocement models of one building, together with a careful look at what the resulting totals do and do not show. It does not claim to be the first study of its kind; the research gap is stated only with respect to the literature reviewed.

2. REVIEW OF RELATED WORK

This review covers the 24 studies in the project reference list. They are summarised from their titles, stated scope and bibliographic details only. Their numerical findings are not quoted, because the full texts have not been checked.

2.1 Mechanical and structural behaviour of ferrocement

Most experimental work on ferrocement deals with thin mortar elements. Kaushik et al. [3] tested the flexural behaviour of ferrocement slab panels containing silica fume and fibres. Two studies on reactive powder concrete (RPC) ferrocement looked at hollow beams reinforced with different mesh types [14] and at beams with a lightweight core [15]. Taken together, they show that ferrocement can be made into slab, hollow and cored sections, with mesh type, matrix composition and core material as the main design variables. None of them quantifies environmental impact or considers a whole building.

2.2 Sustainable ferrocement materials and alternative binders

Al-Hadithi et al. [5] studied the thermal performance of ferrocement slabs reinforced with recycled PET fibres, which links ferrocement to operational energy and to waste-derived materials. Fahim et al. [4] examined pozzolanic waste in ferrocement, and Minde et al. [16] reviewed ferrocement as a sustainable material in the Indian context. In these works the sustainability argument rests mainly on thin sections and material substitution, not on LCA of a complete structure.

2.3 Ferrocement strengthening and retrofitting

A large part of the ferrocement literature treats it as an outer layer or jacket on existing members. Examples include strengthening of RC beams using recycled clay bricks and natural fibres [17], analysis of a ferrocement-strengthened RC beam [18], retrofitting of damaged RC beams [19], post-fire rehabilitation of RC columns [20] and columns wrapped with ferro-geopolymer composites [21]. This work supports the structural credibility of ferrocement and points to alternative binders that could be assessed later. It does not, however, consider ferrocement as the main structural system of a new building.

2.4 BIM-based LCA and embodied-carbon assessment

Morsi et al. [22] used BIM-based LCA to compare structural-system scenarios for a residential building, which makes their study the closest methodological precedent for the present work. Ma et al. [23] and Kanangkaew et al. [24] applied BIM-integrated LCA to high-rise structures; the second adopted a localised approach for Thailand. Kumar et al. [25] assessed the whole-life carbon of a single-family house in North India. Abdelaal et al. [26] combined BIM, LCA and the analytic hierarchy process so that environmental results could be weighed against other decision criteria, and Alwan et al. [1] proposed a parametric framework for operational and embodied energy.

2.5 BIM–LCA integration, datasets and automated mapping

Several studies focus on the technical link between BIM and LCA. Parece et al. [2] built a BIM tool around a construction classification system, Zou et al. [10] proposed an early-stage workflow using reusable assembly templates and rule-based mapping, and Petrosa et al. [13] reported an AI-driven tool for matching model elements to LCA datasets. The reviews by Soust-Verdaguer et al. [12], Teng et al. [11], Tosi et al. [27] and a 2025 systematic review [28] agree that BIM–LCA is fast and repeatable, but that the results depend on how complete the model is, how materials are mapped, and which system boundary and datasets are chosen.

2.6 Research gap and present contribution

In the reviewed set, ferrocement research is mostly at element level and mechanical in focus [3], [14], [15], [17]–[21], while BIM–LCA research deals with conventional structural systems [22]–[26]. Matching ferrocement mortar and mesh to environmental datasets remains an open practical question [2], [10], [13], [28]. Evidence for a like-for-like, whole-building BIM–LCA comparison of ferrocement and RCC is therefore thin in the reviewed literature. This does not mean that no such study exists. The present work addresses the gap by comparing two models of a single building under one set of boundaries, and by openly examining the quality of the data behind the comparison.

3. CASE STUDY

3.1 Building and model alternatives

The case study is a G+3 framed building (ground floor plus three upper floors) with isolated footings, a hipped roof and external walls with openings, modelled in Autodesk Revit (Fig. 1). Both alternatives were meant to share the same geometry so that the structural material is the main difference: one model is RCC and the other is ferrocement. In Navisworks the levels are named Level 0 to Level 4 and correspond to the foundation, ground floor, first floor, second floor and third floor. The structural system consists of footings, columns, beams, floor slabs and stairs. The architectural elements are the external walls, internal walls and partitions, façade openings and the roof.

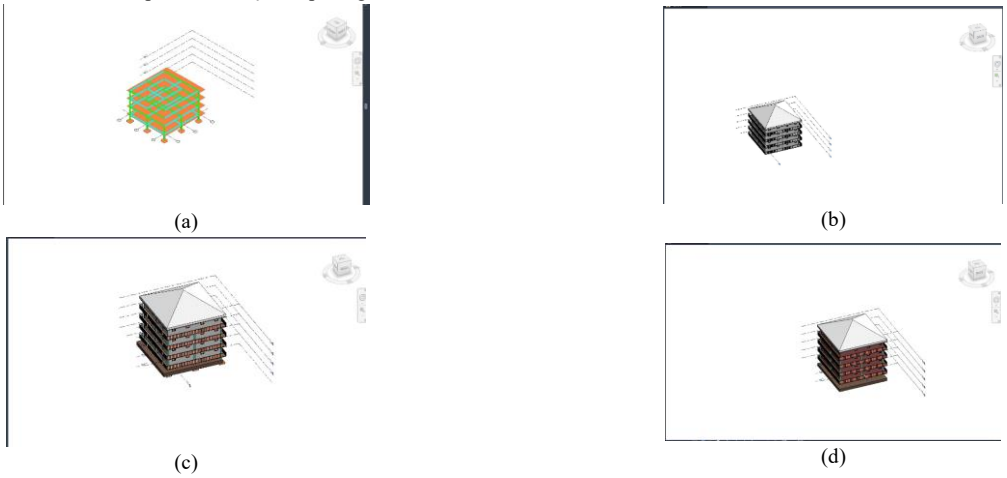


Fig. 1. Autodesk Revit 3D views of the building models: (a) structural frame (footings, columns, beams and slabs); (b) ferrocement model, architectural elements alone; (c) ferrocement model, structural plus architectural elements; (d) RCC model, structural plus architectural elements.

3.2 Model scenarios

To separate the contribution of the structure from that of the architectural elements, results were produced for several model states (Table 1). The group of results titled “Structural Alone” in the project file does not state its material system. It is treated here as the ferrocement structural-only case, because the other groups name their system, but this labelling has not been confirmed. No RCC structural-only result was supplied.

Table 1. Model scenarios and available GWP results.

Scenario	Material system	GWP (t CO_2e)
Structural elements alone	Presumed ferrocement	190
Architectural elements alone	Ferrocement	2,894
Structural + architectural	Ferrocement	3,107
Architectural elements alone	RCC	3,002
Structural + architectural	RCC	3,215
Structural elements alone	RCC	Not supplied

3.3 Structural components and material definitions

In the One Click LCA output, the structural components fall under the classes 1.1 Foundations (substructure), 1.2 Load-bearing structural frame, 1.3.1 Ground floor slab and 1.3.3 Stairs and ramps. Walls, façade openings and partitions fall under 1.2.3 External walls, 1.3.2 Internal walls, partitions and doors, and 1.4.2 Façade openings. Two materials were defined for ferrocement in the Revit material browser: ferrocement mortar and galvanized steel wire mesh. Table 2 lists the thermal-asset values stored in Revit. These describe thermal behaviour and density, not structural strength, and the mortar asset is based on a cement-plaster entry in the Revit library. For the RCC model, the supplied screenshots show only an air infiltration barrier and common brick (density 1,820 kg/m³, thermal conductivity 0.811 W/m·K). The concrete grade, density and reinforcement details of the RCC frame are not documented.

Table 2. Revit thermal-asset properties of the ferrocement materials (from the supplied screenshots).

Property	Ferrocement mortar	Galvanized steel wire mesh
Thermal conductivity (W/m·K)	1.2000	50.0000
Specific heat (J/g·°C)	0.8800	0.4800
Density (kg/m³)	2,300	7,850
Emissivity	0.90	0.80
Porosity	0.01	Not shown
Permeability (ng/Pa·s·m²)	216.6	Not shown

3.4 Roles of the software tools

Each tool had a separate job. Autodesk Revit was used to model the building, define materials and generate material take-off schedules. One Click LCA calculated the environmental impacts from the extracted quantities. Autodesk Navisworks Manage (TimeLiner) was used only to visualise the planned construction sequence of the structural frame, from the foundation to the third-floor slab, as a four-dimensional (4D) simulation. TimeLiner does not calculate carbon and was not an input to the LCA; the construction-stage (A5) result is the value calculated by One Click LCA. The 4D exercise and the carbon assessment are therefore two separate pieces of work.

3.5 Information unavailable for reproducibility

The project files do not state the building use, location, plan dimensions, structural grid, floor-to-floor height or gross floor area (GFA). They also lack the RCC member sizes, concrete grade, reinforcement grade and quantities; the ferrocement thickness, mortar mix and mesh specification; the Revit material take-off schedules; and the One Click LCA dataset names, geographic scope and mapping of Revit materials to resources. None of these items has been assumed, so the study cannot be reproduced from this paper alone.

4. METHODOLOGY

4.1 Research design and goal

The study is a comparative, model-based assessment of the embodied carbon of one building represented in two structural alternatives. It follows the four LCA phases of ISO 14040 and ISO 14044 [6], [7]: goal and scope, inventory, impact assessment and interpretation. The goal is to compare the global warming potential (GWP) of the RCC and ferrocement models and to identify the main contributors. Fig. 2 summarises the workflow. The Navisworks step runs alongside the other steps and does not feed into the LCA calculation.

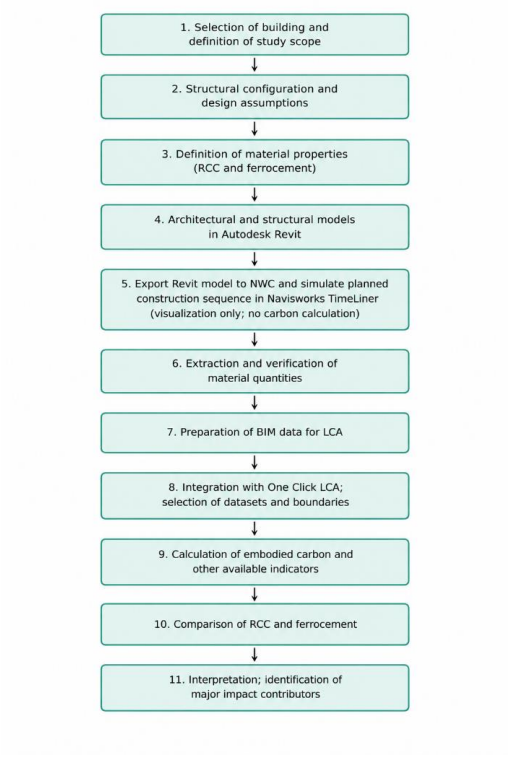


Fig. 2. BIM-based LCA methodology flowchart. The Navisworks TimeLiner step (step 5) is for construction-sequence visualisation only and involves no carbon calculation.

4.2 Assessment scope and functional unit

The assessment covers the building structure and its architectural elements. The functional unit of the supplied results is the whole building as modelled. A per-square-metre unit could not be used, because the gross floor area and the assessment period were left at 1 in the software. Operational energy is outside the assessment, as the mandatory energy-consumption field of the Level(s) framework was not filled in.

4.3 BIM model development

The RCC and ferrocement models were built in Revit with the same intended geometry. So that impacts could be attributed separately, results were generated for the architectural elements alone, the structural elements alone and the combined model (Table 1).

4.4 Material definition and quantity extraction

Quantities were taken from Revit material take-off schedules, which list volume, area or mass for each material and category. The embodied carbon of the assessed system is then

$$EC = \Sigma\,(Q_i \times EF_i) \tag{1}$$

where EC is the embodied carbon (kg CO_2e), Q_i is the quantity of material i (m^3, kg or m^2, matching the unit of the dataset) and EF_i is the emission factor of that material (kg CO_2e per unit of Q_i) for the declared life-cycle modules. Volumes and masses are obtained from

$$V = A \times t \;\text{(areal elements)}; \quad V = b \times d \times L \;\text{(linear elements)} \tag{2}$$

$$m = V \times \rho \tag{3}$$

where V is volume (m^3), A is area (m^2), t is thickness (m), b, d and L are section width, depth and length (m), m is mass (kg) and ρ is density (kg/m^3). Planned quality checks were: hand calculation of sample volumes, confirmation that no element has a missing or default material, avoidance of double counting at joints, and confirmation that the two models differ only where the structural systems differ. The Revit take-off schedules themselves were not available for this paper.

4.5 Mapping of quantities to environmental datasets

In One Click LCA, each quantity was linked to a resource type and its environmental dataset. The resource types that appear in the results include structural steel and steel profiles, mortar, sand, soil and gravel, ready-mix concrete, plastic membranes, cross-laminated timber (CLT), glulam and laminated veneer lumber (LVL), aluminium, glass wool and polyurethane (PUR) insulation, common clay brick, and hot-dip galvanized steel. The supplied screenshots do not show clearly which Revit material was linked to which resource type, nor the dataset names and their geographic scope, so these are not stated here. The software was the One Click LCA education (student) licence.

4.6 Assessment framework and modules

The assessment used the Level(s) framework based on EN 15804+A1, with information modules following EN 15978 and EN 15804 [8], [9]. Table 3 shows which modules appear in the supplied results. The use stage (B1–B7), deconstruction (C1) and module D are not reported. The study is therefore a partial assessment of embodied impacts and not an assessment of the complete building life cycle.

Table 3. Life-cycle modules and their presence in the supplied results.

Module	Description	In results
A1–A3	Product stage (raw materials, transport, manufacturing)	Yes
A4	Transport to site	Yes
A5	Construction and installation process	Yes
B1–B7	Use stage	No
C1	Deconstruction and demolition	No
C2	Waste transport	Yes
C3	Waste processing	Yes
C4	Waste disposal	Yes
D	Benefits and loads beyond the system boundary	No

4.7 GWP calculation and comparison

The total GWP is the sum of the reported modules. Carbon intensity (CI) would normalise this total by the gross floor area:

$$GWP\text{total} = GWP\text{A1–A3} + GWP\text{A4} + GWP\text{A5} + GWP\text{C2} + GWP\text{C3} + GWP\text{C4} \tag{4}$$

$$CI = GWP\text{total} / GFA \tag{5}$$

where GWPtotal is in kg CO_2e, GFA is the gross floor area (m^2) and CI is in kg CO_2e/m^2. Since the GFA is not available, CI is not evaluated. The two models are compared using the relative difference and the contribution shares:

$$\Delta\,(\%) = [(GWP\text{RCC} - GWP\text{Ferro}) / GWP\text{RCC}] \times 100 \tag{6}$$

$$Share_i\ (\%) = (GWP_i / GWP\text{total}) \times 100 \quad (7)$$

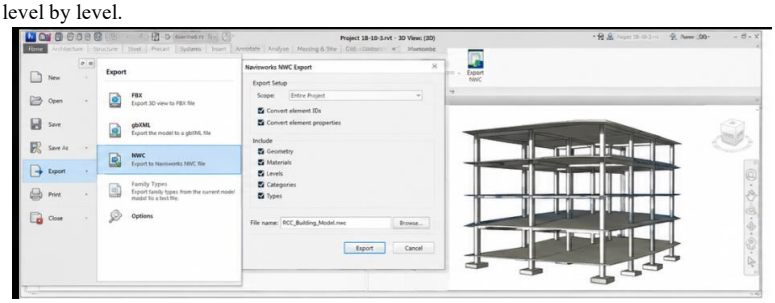
where a positive Δ means a lower GWP for the ferrocement model, and $Share_i$ is the contribution of module, building-element class or resource type *i*.

4.8 Identification of contributors

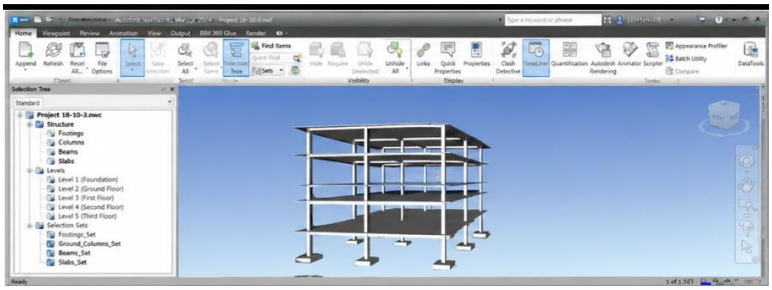
Contributions were identified by life-cycle module, building-element class and resource type, using the charts produced by One Click LCA. The "implied structural part" was obtained as (structural + architectural) − (architectural alone). Percentages were read from the charts as displayed, and some labels are truncated, so values marked as derived or inferred should be replaced with exported data tables.

4.9 Planned construction sequence in Navisworks TimeLiner

The Revit model was exported in Navisworks Cache (NWC) format and opened in Navisworks Manage (Fig. 3). Elements were grouped by category, level and type into selection sets and linked manually to TimeLiner tasks of type Construct (Fig. 4). The planned programme has 37 activities for the structural frame, from the foundation to the third-floor slab, and runs from 3 August 2026 to 30 November 2026. It rests on the following assumptions: a start date chosen to meet a target completion of 30 November 2026, a six-day working week, indicative durations not derived from productivity rates, 7-day curing after each concreting activity, and no allowance for holidays or delays, which leaves no float. It is a baseline for visualisation, not a record of site work, and it has not been checked against site data (Table 4). TimeLiner does not calculate a critical path or carbon. The simulation frame in Fig. 5 shows the structure appearing level by level.



(a) Navisworks export from Revit



(b) Model in Navisworks

Fig. 3. (a) Export of the Revit model in NWC format and (b) the model view in Navisworks Manage used for the construction sim ulation.

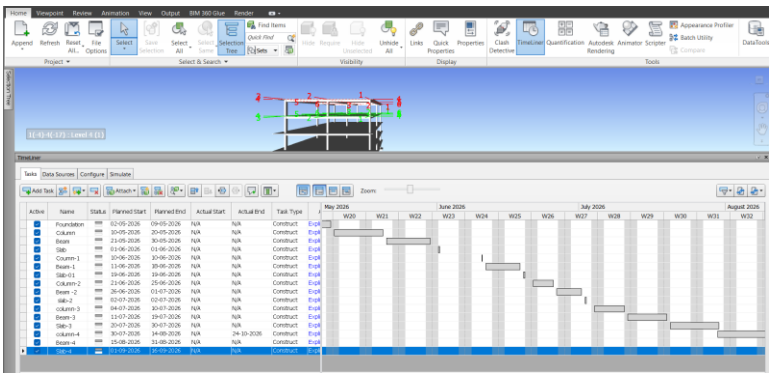


Fig. 4. Construction activities defined in TimeLiner (screenshot from the project file). The task list is coarser than Table 4 and shows planned dates from 2 May 2026; the two have not been reconciled.

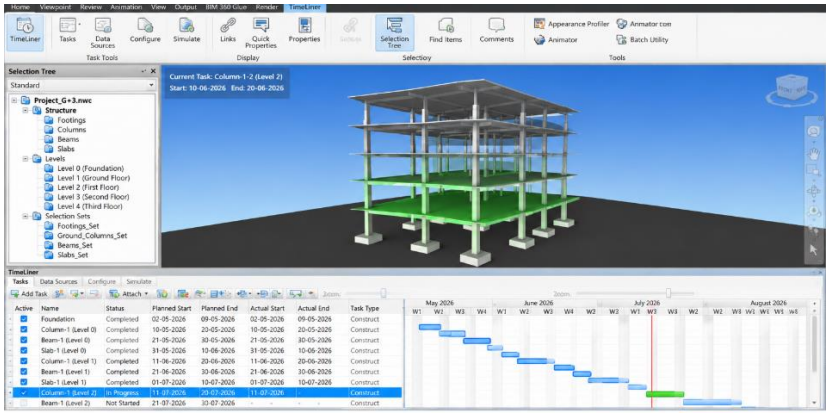


Fig. 5. Planned construction sequence simulation frame for the G+3 building (screenshot from the project file). Dates displayed are those of the project file and differ from Table 4.

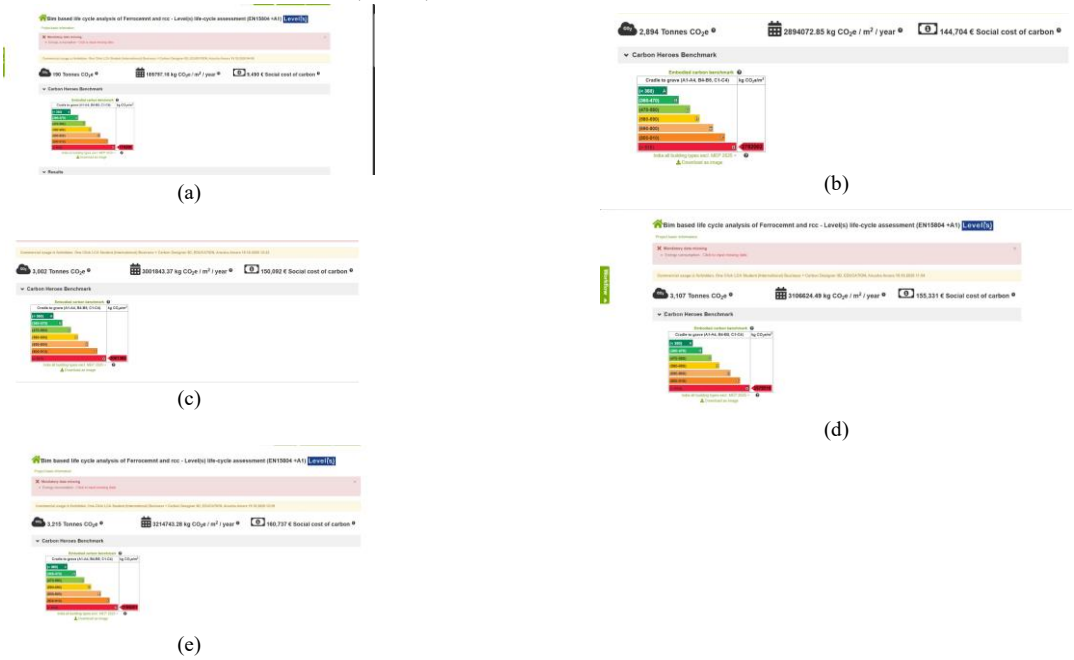
Table 4. Milestones of the planned 37-activity programme (3 August to 30 November 2026; 103 working days).

Planned milestone	Date (2026)
Substructure to plinth level (A01–A13)	Finish 21 September
Ground-floor slab concreting	7 October
First-floor slab concreting	22 October
Second-floor slab concreting	6 November
Third-floor slab concreting	21 November
Third-floor slab curing (A37)	Finish 30 November

5. RESULTS AND DISCUSSION

5.1 Total global warming potential

Fig. 6 shows the One Click LCA summaries for the five supplied scenarios. The totals in kg CO_2e are those shown in the field labelled "kg CO_2e/m^2/year"; they equal the total emissions because the area and period were left at 1. The social cost of carbon reported by the software corresponds to €50 per tonne CO_2e. The ferrocement model (structural + architectural) has a total GWP of 3,107 t CO_2e, and the RCC model 3,215 t CO_2e (Table 5, Fig. 7). This is a difference of about 108 t CO_2e, or 3.4% of the RCC total (Table 6).



(a) (b) (c) (d) (e)

Fig. 6. One Click LCA summaries: (a) structural elements alone (presumed ferrocement); (b) ferrocement, architectural elements alone; (c) RCC, architectural elements alone; (d) ferrocement, structural plus architectural; (e) RCC, structural plus architectural. The per-area values and benchmark class shown are not meaningful because the GFA was not entered.

Table 5. Total GWP of the model scenarios (modules A1–A5 and C2–C4). SCC: social cost of carbon reported by the software.

Scenario	GWP (t CO_2e)	GWP (kg CO_2e)	SCC (€)
Ferrocement: structural + architectural	3,107	3,106,624.49	155,331
RCC: structural + architectural	3,215	3,214,743.28	160,737
Ferrocement: architectural alone	2,894	2,894,072.85	144,704
RCC: architectural alone	3,002	3,001,843.37	150,092
Structural alone (presumed ferrocement)	190	189,797.16	9,490

Table 6. Differences between the RCC and ferrocement models. † Derived: (structural + architectural) − (architectural alone).

Comparison	RCC (t CO_2e)	Ferrocement (t CO_2e)	Difference
Structural + architectural	3,214.7	3,106.6	108.1 t (3.36% of RCC)
Architectural alone	3,001.8	2,894.1	107.8 t (3.59% of RCC)
Implied structural part†	212.9	212.6	0.35 t (0.16% of RCC value)

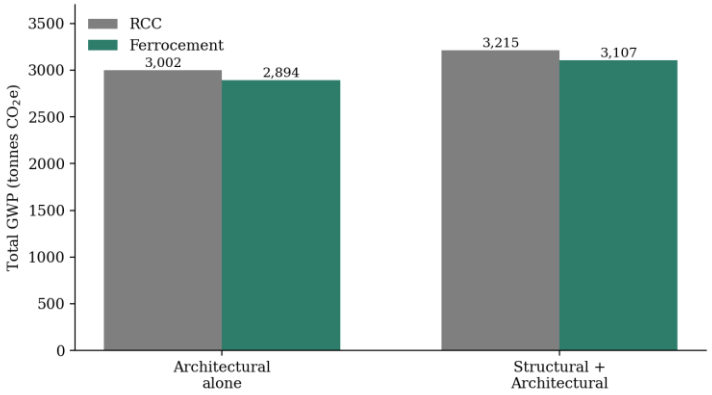


Fig. 7. Total GWP of the RCC and ferrocement model scenarios (t CO_2e).

5.2 Life-cycle stage contributions

In both models the product stage (A1–A3) accounts for about 95% of the total (94.8% for ferrocement and 94.7% for RCC). Construction (A5) contributes about 4%, transport (A4) and waste transport (C2) each contribute less than 1%, and C3 and C4 are close to zero (Table 7, Fig. 8). The A1–A3 difference between the models, about 99 t when derived from the displayed percentages, is roughly 92% of the 108 t total difference. This dominance of material production is consistent with the emphasis on material-related embodied carbon in other BIM–LCA studies [22]–[25]. For the structural-only case (190 t), the product stage accounts for 91.7% and A5 for 6.2%.

Table 7. Share of GWP by life-cycle module (structural + architectural). ‡ Derived from the displayed percentages and rounded.

Module	Ferro. (%)	RCC (%)	Ferro. (t)‡	RCC (t)‡
A1–A3	94.8	94.7	2,945	3,044
A4	0.4	0.5	12.4	16.1
A5	3.8	3.9	118.0	125.4
C2	0.8	0.8	24.9	25.7
C3	0.0	0.0	~0	~0
C4	0.0	0.0	~0	~0

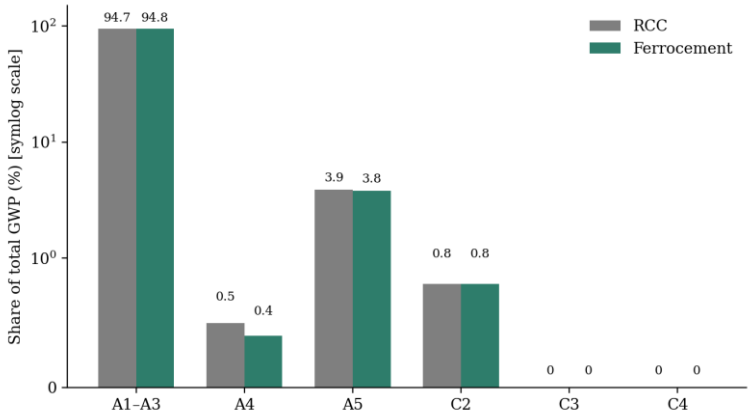


Fig. 8. Share of total GWP by life-cycle module (symmetric-log scale).

5.3 Contributing building elements and materials

Among the element classes, the one labelled "ground floor slab" accounts for about 91% of the GWP in the ferrocement model and 88% in the RCC model (Table 8, Fig. 9). Since the building has several floors, this class probably includes more than one slab, and the element mapping should be checked. Foundations, stairs and ramps, and external walls each contribute only a few per cent.

Table 8. Share of GWP by building-element classification (structural + architectural).

Classification	Ferro. (%)	RCC (%)	Note
1.3.1 Ground floor slab	91.0	87.6	
1.3.3 Stairs and ramps	4.0	3.9	
1.2.3 External walls	2.4	0.7	
1.1 Foundations	2.3	2.2	
1.4.2 Façade openings	0.2	0.3	
Internal walls, frame, other	0.1	5.3	by difference

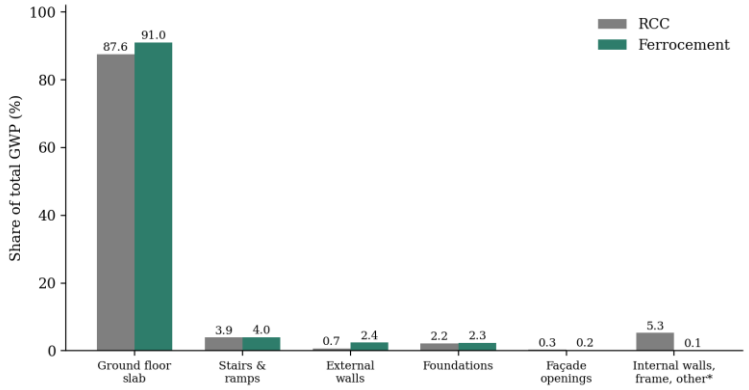


Fig. 9. Share of total GWP by building-element classification.

By resource type (Table 9, Fig. 10), structural steel and steel profiles dominate both models, at about 90% for ferrocement and about 86% for RCC (the chart labels are truncated, and the RCC value is inferred). Mortar contributes 7.4% in the ferrocement model against 2.4% in the RCC model, as expected for a mortar-based system, while the RCC model has additional shares from plastic membranes, CLT/glulam/LVL and aluminium. Differences in such architectural and finishing materials are a plausible but unchecked source of the 108 t difference. Fig. 11 reproduces the charts exported directly from One Click LCA. Fig. 12 shows the total GWP and social cost of carbon for scenarios M1 to M5, where M1 is the ferrocement architectural-only model, M2 the structural-only model (presumed ferrocement), M3 the ferrocement combined model, M4 the RCC architectural-only model and M5 the RCC combined model. The social cost is a fixed €50 per tonne, so the two charts have the same shape. Fig. 13 shows the One Click LCA bar-chart view of the ferrocement combined model.

Table 9. Selected shares of GWP by resource type (structural + architectural). Labels in the source charts are partly truncated.

Resource type	Ferro. (%)	RCC (%)
Structural steel and steel profiles	about 90	about 86 (inferred)
Mortar (masonry/bricklaying)	7.4	2.4
Plastic membranes	not listed	4.1
CLT, glulam and LVL	not listed	1.9
Aluminium	not listed	1.0
Sand, soil and gravel	0.7	0.8
Glass wool insulation	not listed	0.7
Common clay brick	not listed	0.7

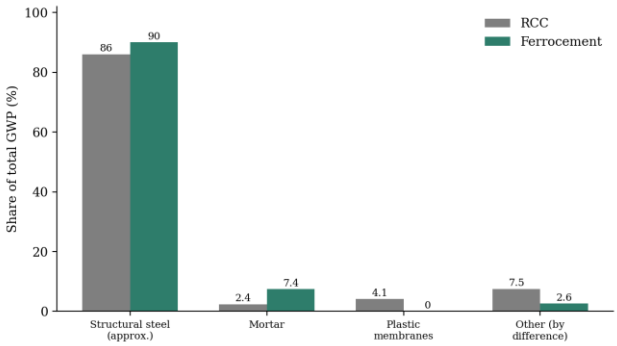


Fig. 10. Share of total GWP by resource type (selected; "other" obtained by difference).



(a) (b) (c) (d)

Fig. 11. Charts exported from One Click LCA: (a) ferrocement model, GWP by life-cycle stage and classification; (b) RCC model, same charts; (c) ferrocement model, GWP by resource type and mass by classification; (d) RCC model, same charts.



(a) Total GWP (t CO_2e) (b) Social cost of carbon

Fig. 12. Scenarios M1–M5: (a) total GWP (t CO_2e) and (b) social cost of carbon (€).

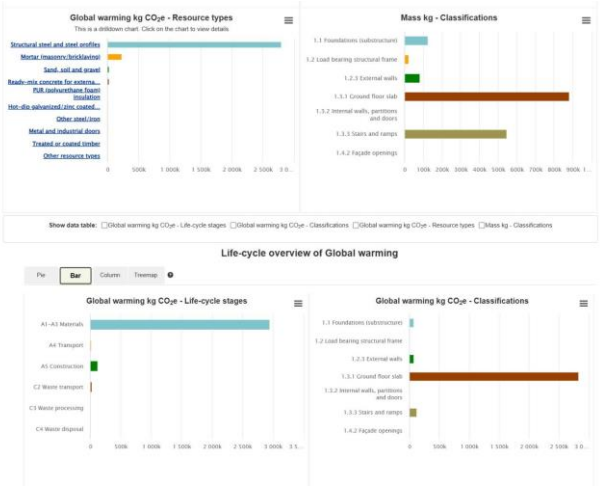


Fig. 13. One Click LCA bar-chart results for the ferrocement model (structural plus architectural elements).

5.4 Critical interpretation

The implied structural frame contributes about 213 t CO_2e in each model (212.9 t for RCC and 212.6 t for ferrocement). The architectural-only totals differ by almost exactly the amount by which the combined totals differ (107.8 t against 108.1 t). The whole difference therefore sits in the architectural portion, where the two models are meant to be identical, and not in the frame, where RCC and ferrocement differ in principle. **The 3.4% lower combined total must not be taken as evidence that a ferrocement frame has lower embodied carbon.** Two explanations are possible. Either the structural quantities genuinely give nearly the same GWP, or the two frames were mapped to similar materials, in which case ferrocement was not really tested as a structural material. The cause of the architectural difference, for example different wall layers, finishes, membranes or roof materials, has not been checked against the material lists of the two models.

5.5 Consistency checks and data quality

Four data-quality points limit how far the results can be trusted. First, steel dominance (86–90%) with only a small share for cement-based materials is unusual, because concrete and mortar normally contribute substantially to the embodied carbon of buildings; the mapping or units of concrete and reinforcement may need correcting. Second, the structural-alone result (190 t) does not match the implied structural part (212.6 t). This gap of about 23 t is not explained in the supplied material and has not been reconciled here. Third, the GFA was not entered, so the per-area values and the benchmark

class displayed by the software (Fig. 6) are not meaningful and are not interpreted. Fourth, the totals are single whole-building values; no uncertainty or sensitivity analysis was carried out, and no statistical significance is claimed.

5.6 Why consistent modelling matters

Structural alternatives can only be compared meaningfully when geometry, material quantities, functional unit, dataset representativeness and assessment boundaries are the same, and when the alternatives are functionally equivalent. The BIM–LCA reviews stress the same point [11], [12], [27]. The unresolved architectural difference and the uncertain mapping of ferrocement mortar and mesh [2], [13] show how modelling and data choices alone can produce differences of the size reported here. Durability and maintenance, which feature strongly in the ferrocement rehabilitation literature [19], [20], lie outside the assessed boundary. Measures that reduce the impact of ferrocement mortar, such as pozzolanic waste, recycled fibres or geopolymer binders [4], [5], [21], would improve the result only modestly here, since mortar contributes 7.4% of the GWP and steel is the larger lever.

5.7 Hypothesis and role of the 4D visualisation

The working hypothesis that ferrocement can reduce environmental impact compared with RCC is only weakly supported. The direction of the total difference agrees with it, but the difference is small, arises outside the frame and is affected by the data-quality issues above. The TimeLiner simulation shows the planned order of construction (footings, column stubs, plinth beams and then the floor cycles). It helps with communication and planning but adds nothing to the environmental results. The task dates in the TimeLiner screenshots (from 2 May 2026) differ from the 37-activity programme (3 August to 30 November 2026), and the two have not been reconciled.

6. LIMITATIONS

The project report documents the following limitations:

1. The results apply only to this model, its modelling assumptions and the datasets available in One Click LCA. They cannot be generalised to other buildings without further case studies.
2. The architectural-only totals differ by about 108 t between models whose architectural elements were meant to be the same, so equivalence of the architectural quantities is not confirmed.
3. Building dimensions, structural grid, storey heights, member sizes, concrete and reinforcement grades, and the ferrocement mix and mesh specification are not documented.
4. The mapping of ferrocement mortar and wire mesh to environmental datasets is uncertain, and the dataset names and geographic scope are not available.
5. No structural design check shows that the two alternatives have equal load capacity, and no experimental testing was done.
6. Use-stage and operational-energy impacts, C1 and module D are excluded. The GFA was not entered, so carbon intensity per square metre could not be evaluated.
7. The Navisworks schedule is a planned programme with indicative durations. It has not been validated against site progress, covers only the structural frame, and its dates are not reconciled with the TimeLiner screenshots.

The following points have not yet been verified and cannot be treated as established: whether the structural frames in the two models were really mapped to different materials; the origin of the gap of about 23 t between the structural-alone result and the implied structural part; whether the “ground floor slab” class contains all floor slabs; the material system of the structural-alone result; the truncated steel percentages; and whether the steel dominance reflects a mapping or unit error.

7. CONCLUSION

This study compared RCC and ferrocement versions of a G+3 building using a BIM–LCA workflow: Autodesk Revit for modelling and quantity extraction, One Click LCA (Level(s), EN 15804+A1) for the assessment, and Navisworks TimeLiner for a supporting 4D visualisation that is not an input to the carbon calculation. For modules A1–A5 and C2–C4, the total GWP was 3,107 t CO_2e for the ferrocement model and 3,215 t CO_2e for the RCC model, a difference of about 108 t CO_2e. The ferrocement total is about 3.4% lower, but this does not show that the ferrocement structural frame has lower embodied carbon. The implied frame contribution is about 213 t CO_2e in both models, and the whole difference arises in the architectural portion. The product stage (about 95%) and steel, the largest resource contributor, dominate both results.

Extracting quantities from the BIM models gave a consistent basis for the assessment and made the main contributors easy to identify. The 4D visualisation described the planned construction sequence but did not contribute to the carbon result. The potential of ferrocement as a lower-carbon structural system is plausible, but this study does not prove it.

Future work should (i) verify the equivalence of the two models and resolve the architectural difference; (ii) design both frames for equivalent structural capacity; (iii) use material-specific datasets or environmental product declarations for ferrocement mortar and mesh; (iv) carry out sensitivity analysis on datasets and quantities; (v) enter the GFA and report carbon intensity; (vi) extend the boundary to the use stage, C1 and module D, and to further impact categories; (vii) examine alternative binders and recycled fibres [4], [5], [21]; and (viii) repeat the study for additional buildings.

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