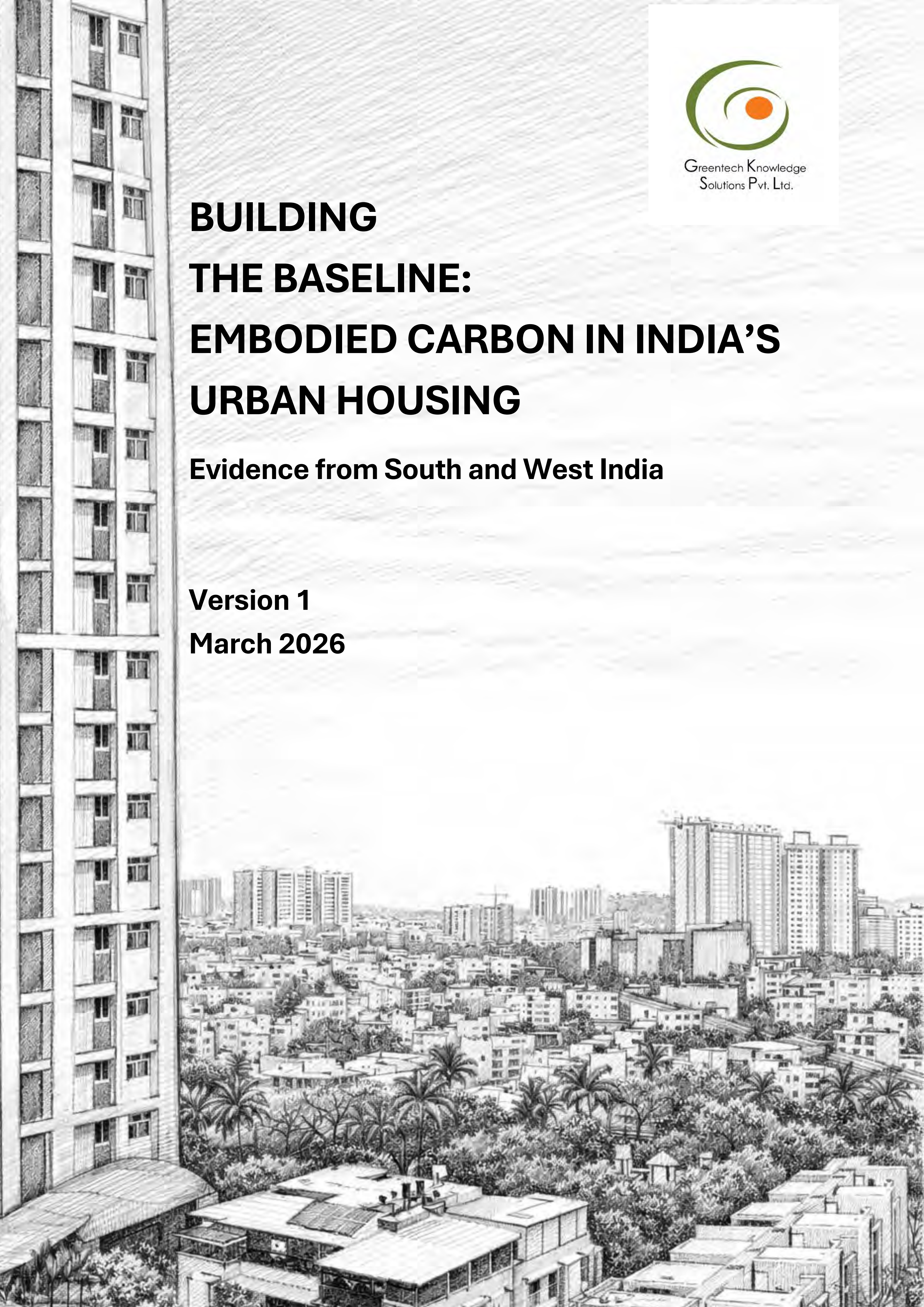

Greentech Knowledge Solutions Pvt. Ltd.

BUILDING THE BASELINE: EMBODIED CARBON IN INDIA'S URBAN HOUSING

Evidence from South and West India

Version 1

March 2026

This study has been carried out by Greentech Knowledge Solutions Pvt. Ltd (GKSPL).

GKSPL is a research and advisory firm which offers services and solutions for improving energy efficiency in buildings, improving resource efficiency in the production of building materials and building decarbonisation. GKSPL has worked in the domains of building energy efficiency, resource-efficient building materials and renewable energy integration, by conducting technical research, providing policy support and facilitating transition through technical support, capacity building and policy implementation. **(www.gkspl.in)**

Authors and core project team
- Saswati Chetia (GKSPL)
- Nivit Mital (GKSPL)
- Sonija Kapooria Phogat (GKSPL)
- Vernica Prakash (GKSPL)
- Sameer Maithel

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AI Use Statement
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Any errors or omissions remain solely the responsibility of the authors.

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Abbreviations

AAC	Autoclaved Aerated Concrete
BIM	Building Information Modeling
BoQ	Bill of Quantities
BUA	Built-up Area
CARBSE	Centre for Advanced Research in Building Science and Energy
CATE	Comfort At The Extremes
CCTS	Carbon Credit Trading Scheme
CEF	Carbon Emission Factor
CII	Confederation of Indian Industry
CLF	Carbon Leadership Forum
CSEB	Compressed Stabilised Earth Block
CSTEP	Center for Study of Science, Technology and Policy
DGU	Double Glazed Unit
EC3	Embodied Carbon in Construction Calculator
ECSBC	Energy Conservation and Sustainable Building Code
EJ	Exajoule
EPD	Environmental Product Declaration
ESG	Environmental, Social, and Governance
FU	Functional Unit
GCCA	Global Cement and Concrete Association
GFA	Gross Floor Area
GGBS	Ground Granulated Blast-furnace Slag
GHG	Greenhouse Gases
GIA	Gross Internal Area
GRIHA	Green Rating for Integrated Habitat Assessment
GWP	Global Warming Potential
HDV	Heavy Duty Vehicle
HSD	High-Speed Diesel
ICE	Inventory of Carbon and Energy

IFC	International Finance Corporation
IGBC	Indian Green Building Council
ILFI	International Living Future Institute
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LCI	Life Cycle Inventory
LT-LEDS	Long-Term Low Emission Development Strategy
LETI	Low Energy Transformation Initiative
LULUCF	Land Use, Land-Use Change, and Forestry
MDV	Medium Duty Vehicle
MEP	Mechanical, Electrical and Plumbing
MSME	Micro, Small, and Medium Enterprise
MT	Metric Tonne
NITI Aayog	National Institution for Transforming India
OPC	Ordinary Portland Cement
PPC	Portland Pozzolana Cement
PSC	Portland Slag Cement
PUF	Polyurethane Foam
RCC	Reinforced Cement Concrete
RIBA	Royal Institute of British Architects
RICS WLCA	Royal Institution of Chartered Surveyors Whole Life Carbon Assessment
RMC	Ready-Mix Concrete
RMI	Rocky Mountain Institute
SCM	Supplementary Cementitious Material
ULB	Urban Local Body
UNEP	United National Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UPVC	Unplasticized Polyvinyl Chloride
VDF	Vacuum Dewatered Flooring

Section 1: India’s Embodied Carbon Challenge

1.1 Locking in carbon: Addressing embodied carbon
1.2 Building lifecycle
1.3 Indian policy and market landscape
1.4 Embodied carbon baselines and benchmarks for decarbonisation

1.1 Locking in carbon: Addressing embodied carbon

By various accounts, India will be the third largest construction market globally by value[12], driven by large infrastructure projects, urbanisation and housing demand. It is estimated that the country needs to add 700-900 million sq.m. of commercial and residential space every year by 2030[3]. As such, the buildings and construction sector are crucial for India's decarbonisation goals.

The buildings and construction sector contributes significantly to global energy demand as well GHG emissions. The buildings sector in India constitutes 30% of the total energy demand of 29.87 EJ and 25.6% of total GHG emissions, without Land Use, Land-Use Change, and Forestry (LULUCF), of 3.49 Gt CO2e[4].

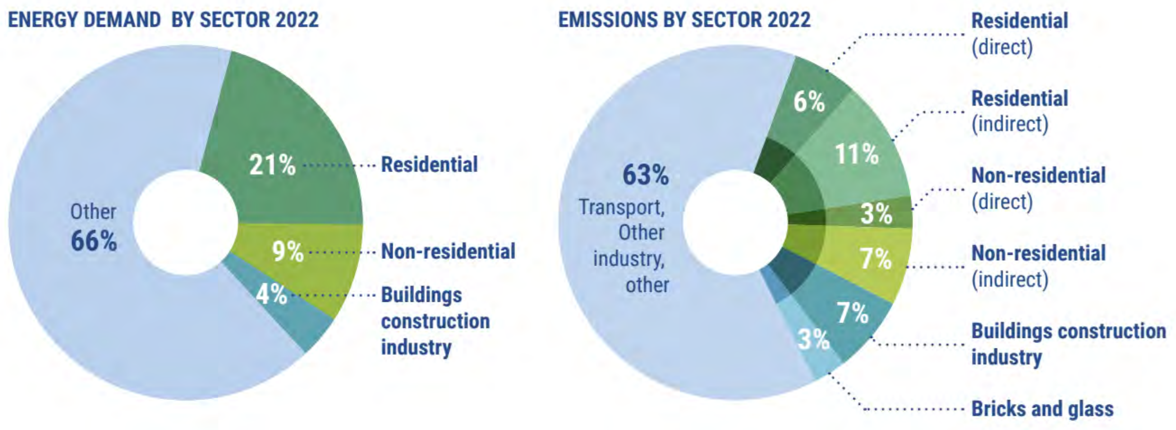


Figure 1: Share of buildings in total global final energy consumptions and global energy and process emissions in 2022 (Source: UNEP, 2024)

The climate debate in the buildings sector in India has focused on operational carbon-emissions due to electricity and fuel used for lighting, cooling, appliances, and other building services. And rightly so, given the anticipated surge in air-conditioning demand due to rising temperatures.

While that remains critical, it is becoming increasingly important to consider embodied carbon—emissions due to extraction, manufacturing, transport, and installation of building materials. Ignoring this would mean India runs the risk of locking in high embodied emissions in its buildings, given the scale of construction anticipated.

1.2 Building lifecycle

The whole-life carbon or carbon footprint of a building is a quantification of GHGs added to the atmosphere by it. It is reported in tonnes of CO2-equivalent (t-CO2e) per unit of comparison and includes emissions for the entire lifecycle of the building. Embodied carbon denotes carbon emissions associated with materials and construction processes and includes stages A1-A5, B1-B5, C1-C4 and D (see below).

UPFRONT CARBON (A1 - A5)

The emissions caused during the building material production and construction phases of the building's lifecycle before it is used. These emissions have already been released into the atmosphere before the building begins operation.

USE-STAGE EMBODIED CARBON (B1 - B5)

Emissions related to the maintenance, repair, replacement and refurbishment of the building throughout its lifetime.

OPERATIONAL CARBON (B6 – B7)

Emissions associated with energy (B6) and water (B7) used to operate the building.

END OF LIFE CARBON (C1 – C4)

Emissions associated with deconstruction, transportation from site, waste processing and disposal of a building which occurs after its use.

BEYOND LIFE BENEFITS (D)

Emissions or emission savings incurred due to recycling /reuse of materials, or emissions avoided due to using waste as fuel source for

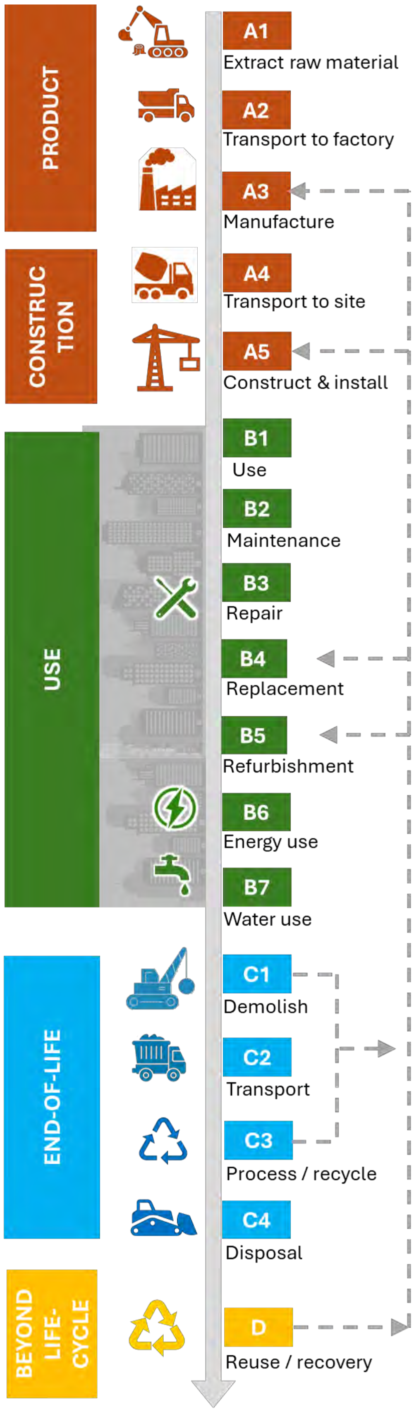


Figure 2: Building lifecycle

1.3 Indian policy and market landscape

WHAT'S THE CURRENT STATUS AND GAPS?

The embodied carbon discussion in the Indian building sector is in a nascent phase but is gaining momentum.

National policy: India has begun recognising whole-life carbon in buildings in policy discussions. Building codes like National Building Code 2025 (draft), Energy Conservation and Sustainable Building Code (ECSBC) 2024 have included sections on embodied carbon impacts. NITI Aayog has also recently published its document on decarbonisation of the building sector titled "Scenarios Towards Viksit Bharat and Net Zero - Sectoral Insights: Buildings (Vol. 5)."

Standards and rating systems: National green building rating bodies (e.g., GRIHA, IGBC) are integrating embodied-carbon concepts into guidance and pilot rating tools. Most of them require embodied carbon reporting at present. Indian market practice increasingly cites ISO or EN standards for building LCA, the GHG Protocol etc. Recently embodied carbon studies are being taken up by various organisations and professional bodies.

Market practice: Large organised real estate developers, building asset management companies and select institutional projects are starting to measure, manage and report emissions from their buildings (with different LCA scopes), often driven by investor or client requirements and mandatory or voluntary ESG reporting.

Lack of nationally endorsed embodied or whole-life carbon calculation methodology: India does not yet have standardised national guidance for whole-life carbon analysis aligned with international frameworks. This leads to inconsistent system boundaries, variable LCA scopes (A1–A5, B, C, or D), and incomparable results among various studies and reports being produced currently, as well as those reported to building rating systems.

No embodied carbon baseline: India has not yet developed baseline values for embodied carbon intensity of buildings as well as thresholds for compliance or performance-based assessment in line with international standards. This follows from the lack of a nationally endorsed embodied carbon calculation methodology.

Lack of national life-cycle inventory / emissions database: India currently lacks a consolidated, publicly available and free national life-cycle inventory for construction materials. For e.g. Switzerland provides this data, taken from the Eco-invent database, for buildings constructed there. A major constraint is the limited availability of Indian lifecycle inventory (LCI) data and verified Environmental Product Declarations (EPDs) for construction materials. As of writing this document EPDs exist only for a small set of about 250 Indian building construction products. International databases, like those from Eco-Invent, ICE etc., do not reflect India's energy mix, plant efficiencies, or transport distances.

Building material industry decarbonisation: The Government of India and the Indian cement and steel industries are engaging in decarbonisation discussions. India has a green steel taxonomy and as of Nov 2025, green steel certificates have been provided to 25 steel mills, three of which are publicly recorded to be 5-star rating. However, for other building materials, mandatory disclosure framework, supply-side verification (EPDs, supplier reporting etc.) and low-carbon product scale-up are still nascent.

Procurement, finance and incentives: Public procurement is currently underutilised but seems to be gaining traction through efforts of various organisations working with procurement policies in specific states. With better supply-side verification (for e.g. green rated steel mentioned above), it is expected that carbon criteria for building materials can be embedded more easily in government procurement. Green financing for buildings increasingly considers whole-life carbon in global markets, but in India green finance and procurement mechanisms targeting embodied carbon are still emerging.

Sub-national policy: City and state-level policies did not address embodied carbon directly. However, in the last 2 years some cities and states are working on green procurement policies, and city-level net-zero building roadmaps that are also looking at embodied carbon.

Knowledge and capacity: Awareness and action around embodied carbon and building LCA are steadily increasing, with a growing number of tools, reporting frameworks, pilot projects, and professional training programs. However, the overall knowledge base and capacity required for robust embodied carbon reporting and compliance remain limited. Large segments of the building ecosystem lack technical understanding, data literacy, and procedural clarity needed to implement consistent embodied and whole-life carbon assessments. India-specific LCA tools and validated material emission databases that are accessible and affordable are essential for mainstreaming LCA practice. However, they are not yet available.

1.4 Embodied carbon baselines and benchmarks for decarbonisation

When talking about decarbonisation of the building sector and reducing embodied carbon, the following four broad principles are mentioned:

- Build nothing: Do we need to build at all?
- Build less: Do we need to build new?
- Build clever: Can we build using less materials?
- Build efficiently: Can we use low carbon materials and waste less?

The first and second opportunities are not applicable for the development needs and goals of India (except for specific cases). Thus, material use intensity (build clever) and material carbon intensity (build efficiently) become the prime focus.

Building-level embodied carbon benchmarks are critical for pushing the case for embodied carbon, but currently India lacks such benchmarks. Such benchmarks:

- **Include the emission reduction opportunity of design efficiency**

Indian policy and industry have made some strides in lowering material carbon intensity and its documentation, most evidently in the cement and steel sector. Carbon benchmarks thus exist for these building materials, in some form[a]. Material benchmarks are supply-side interventions, and that's where much of current policy is being implemented. But without the addition of a design-side intervention benchmark, a key opportunity for emission reduction is missed- that of **Design Efficiency**.

A building-level benchmark can encourage architectural and structural design decisions that reduce material use intensity, while also taking advantage of low-carbon material benchmarks.

- **Provide metric for the building sector's contribution to India's climate goals**

Building level embodied carbon benchmarks can enable building sector contribution to climate goals as well as better documentation. Since floor area is a major driver of GDP, the building benchmark indicates whether we are successfully "decoupling", i.e., growing our built environment while shrinking the carbon footprint per square meter.

[a] *It must be noted that these national material benchmarks may not include emissions from all the life-cycle stages required for an LCA. However, it's a valid data source.*

In 2022, India submitted its Long-Term Low Emission Development Strategy (LT-LEDS) to the UNFCCC, outlining the path to Net Zero 2070. One of the seven pillars of this strategy is "Sustainable Urban Development." Without benchmarks, the "Sustainable Urban Development" pillar remains a vague commitment. Such benchmarks can be used for regulatory action at the city level and financial implementation by including benchmarks in project finance / capital raising considerations.

- **Include other value chain actors into climate action for buildings**

National commitments, related to the buildings sector, usually focus on government, big industry (cement and steel) and power sector. Building-level benchmarks expand this circle to include the value chain actors who make the daily decisions- architects, structural engineers, MSMEs , ESG evaluators, ULBs, and to some extent, the end-users.

Section 2: About this study

2.1 Objective and outputs

As whole-life carbon considerations are being considered and integrated into policy and market frameworks, the lack of consistent embodied-carbon baselines and methodologies remains a major barrier to evidence-based decision-making. This study aims to develop a methodology for reporting, baselining and benchmarking embodied carbon in urban residential buildings.

While initially focused on Bengaluru and Hyderabad, the geographical coverage of the study has been extended to Mumbai-Pune and Kochi. This was done to enable adequate number of building projects to be included in this study within the time frame of the assignment. The study aims to:

- Propose baseline embodied-carbon values for urban housing typologies
- Propose a methodology for embodied-carbon reporting and benchmarking in India
- Prepare decarbonisation roadmap to support the transition to near-zero carbon urban housing that reflects local policies, industry practices and stakeholder perspectives.

Given India's diverse construction practices and material supply chains, expanding such assessments nationwide will be essential for establishing a credible national embodied-carbon baseline and informing future building codes, procurement guidelines and green financing mechanisms targeting embodied and whole-life carbon reduction.

2.2 Boundary of this study

Building typology

Residential building

Multi-family housing that falls within the scope of applicability of Eco-Niwas Samhita (ENS) 2024, i.e. minimum connected load of 100 kilowatt (kW) or contract demand of 120 kilovolt, or or plot area of 3000 m^2

LCA scope

Upfront carbon (A1-A5)

Emissions during building material production (A1–A3), transportation to the building site (A4) and, installing them or using them on-site to construct the building (A5).

Building physical scope

Substructure: Foundations and basements

Envelope: Columns and beams, floors and roof construction, staircase, external walls, doors and windows

Interiors: Interior walls and doors, interior plaster, interior floor

Building age

Up to 5 years

Buildings completed in the last 5 years (i.e. 2020 and later) or currently nearing completion

Geography

South and West India

Bengaluru, Hyderabad, Mumbai, Pune, Kochi

2.3 Standards, baselines and benchmarks

Standards, baselines and benchmarks are complementary elements in shaping how carbon is measured, compared, and reduced across the building sector.

STANDARDS- HOW TO MEASURE IT PROPERLY?

Standards define the methodology and rules for conducting building Lifecycle Analysis (LCA). Thus, they define the methods of calculating various indicators of an LCA, including the Global Warming Potential (GWP) which is metric for the carbon footprint of a building. They specify:

- System boundaries (e.g., life-cycle stages A–D)
- Data quality and documentation requirements
- Procedure for inventory analysis
- List of indicators and calculation procedures for these indicators. Global warming potential (GWP) is one of the indicators.

ISO 14040/44, ISO 21931-1 and EN 15978 are the widely accepted standards for conducting a building LCA. Standards ensure that all assessments are comparable and scientifically robust, forming the foundation for baselines and regulations.

BASELINES AND BENCHMARKS- WHAT IS TYPICAL / WHAT IS GOOD?

Baselines and benchmarks provide quantitative reference values for carbon intensity—typically expressed as kg CO_2e/m^2 for building typologies.

They help establish typical performance (baseline) and best-in-class performance (benchmark). These values enable evaluation of performance and form the evidence base for future policy targets, caps, or incentives. Baselines and benchmarks are used by codes and rating systems to form mandates (for reporting, procurement etc.) and rewarding (points in rating systems).

2.4 Embodied carbon benchmarks: Components

Embodied carbon benchmarks generally include:

LIFE-CYCLE STAGES CONSIDERED

Most existing benchmarks cover A1-A5. Others include C1-C4 and some stages of the use-stage embodied carbon.

BUILDING TYPOLOGY

Usually, separate benchmarks are set for different building typologies.

BUILDING COMPONENTS CONSIDERED

Most benchmarks consider substructure (foundation and basements), envelope (above-ground column, beams, floor and roof elements, external walls, external doors and windows); and interiors (internal walls / partitions, doors and wall, floor and ceiling finishes). Some may also include MEP elements and external site works.

FUNCTIONAL UNIT

This is typically denoted as kg CO_2e / m^2, where the total embodied carbon is normalised over the area of the building. This normalisation area, however, is different for different benchmarks (see box below).

NORMALISATION AREAS USED FOR EMBODIED CARBON BENCHMARKING

Gross Floor Area (GFA): sum of the covered areas of all floors of a building, other than the roof, and areas covered by external walls and parapet on these floors. *Comparable to Built-up area (BUA) used in India*.

Gross Internal Area (GIA): area of a building measured to the internal face of the perimeter walls at each floor level. It excludes open-sided balconies and canopies.

Net internal area / Habitable area: the usable area within a building measured to the internal face of the perimeter walls at each floor level. Excludes area occupied by internal walls, non-habitable spaces, circulation areas, lift-wells, stairwells etc. *Comparable to Carpet area used in India, with the exception that carpet area includes the area occupied by internal walls*.

2.5 Existing embodied carbon baselines and benchmarks

360
kg CO_2e/m^2
Median value

420
kg CO_2e/m^2
Average value

ONE CLICK LCA STUDY FOR EUROPEAN BUILDNGS (for multifamily residential)[5]

Geography: Europe
Life cycle Scope: A1-A5, B4-B5, C1-C4
Physical scope: Substructure and Envelope. Interior finishes, MEP and external materials are optional
Normalization area: Gross Internal Area (GIA)

< 625
kg CO_2e/m^2

RIBA 2030 CLIMATE CHALLENGE 2030 BUILD TARGET (for residential)[6]

Geography: UK
Life cycle Scope: A1-A5, B1-B5, C1-C4 including sequestration
Physical scope: Substructure, Envelope, Interiors, MEP and associated refrigerant leakage
Normalization area: Gross Internal Area (GIA)

< 300
kg CO_2e/m^2

LONDON ENERGY TRANSFORMATION INITIATIVE (LETI) 2030 DESIGN TARGET (for residential 6+ storeys)[7]

Geography: UK
Life cycle Scope: A1-A5
Physical scope: Substructure, Envelope, Interiors, MEP
Normalization area: Gross Internal Area (GIA)

< 350

$kg\ CO_2e/m^2$

INTERNATIONAL LIVING FUTURE INSTITUTE (ILFI) EMBODIED CARBON THRESHOLD GOAL[8]

Geography: Global

Life cycle Scope: A1-A5

Physical scope: Substructure, Envelope, Interiors, Site materials

Normalization area: Gross floor area, including structured parking, but NOT including unenclosed exterior spaces such as balconies, or exterior surface parking

370

$kg\ CO_2e/m^2$

CARBON LEADERSHIP FORUM (CLF) EMBODIED CARBON BUDGET 50TH PERCENTILE (for multifamily residential)[9]

Geography: North America

Life cycle Scope: A1-A5

Physical scope: Substructure, Envelope, Interiors

Normalization area: Gross Floor Area, but excluding enclosed parking space whether above or below grade

700

$kg\ CO_2e/m^2$

INDIAN GREEN BUILDING COUNCIL (IGBC) NET ZERO CARBON RATING SYSTEM[10]

Geography: India

Life cycle Scope: A1-A4

Physical scope: Substructure, Envelope

Normalization area: Built-up Area

2.6 Whole-life carbon benchmarks

A few countries have set whole-life carbon benchmarks. Usually, they integrate embodied and operational carbon into one single benchmark. However, there are exceptions like the RE2020 benchmark in France. The functional units of these benchmarks may be kg-CO_2e / m^2, where the whole-life carbon is normalised over the area of the building. Another benchmark used is kg-CO_2e / m^2/yr with a reference period. Some examples are given here.

650
kg CO_2e/m^2

RÉGLEMENTATION ENVIRONNMENTALE- RE2020 (for apartments) 2024-27 THRESHOLD[11]

Geography: France (mandatory regulation)
Life cycle Scope: A1-A5, B1-B4, B7, C1-C4, D (Embodied carbon)
Physical scope: Substructure, Envelope, Interiors, MEP, Site works, All services
Normalization area: Habitable area. Comparable to net internal area / carpet area.
Reference study period: 50 years

320
kg CO_2e/m^2
connected to urban heating network

260
kg CO_2e/m^2
not connected to urban heating network

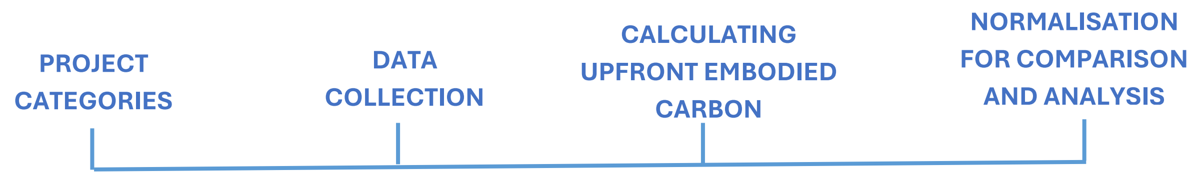
Life cycle Scope: B6
Normalization area: Habitable area. Comparable to net internal area / carpet area.
Reference study period: 50 years

7.5
kg CO_2e/m^2/yr

BYGNINGSREGLEMENTET (BR25) (for apartments)[12]

Geography: Denmark (mandatory regulation)
Life cycle Scope: A1-A5, B4, B6, C3-C4, D
Physical scope: Substructure, Envelope, Interiors, MEP
Normalization area: Gross Floor Area
Reference study period: 50 years

2.7 Study methodology



PROJECT CATEGORIES

This study initially focused on Bengaluru and Hyderabad. Later, projects from Mumbai / Pune and Kochi were also added to have greater number of participating projects. The participating projects are mainly categorised on the basis of height and construction technology.

26 participating projects	**12** Bengaluru	**3** Hyderabad	**9** Mumbai	**2** Pune & Kochi

15 High-rise Monolithic Concrete	**4** High-rise RCC frame + masonry	**1** Mid-rise Monolithic Concrete	**2** Mid-rise RCC frame + masonry	**4** Low-rise RCC frame + masonry

In addition, two more parameters are kept in mind in classifying the projects- the seismic zone classification of the location and the type of parking (basement, podium, stilt).

HEIGHT CATEGORIES

Low rise: Up to 4 storeys
Mid-rise: 5 to 12 storeys
High-rise: Above 12 stories

CONSTRUCTION TECHNOLOGY

Monolithic Concrete Construction

Here instead of the traditional column and beam construction, all walls, floors, slabs, columns, beams, stairs, together with door and window openings are cast in place in one operation at site by use of modular aluminium or PVC formwork. Aluminium formwork is more common. This type of construction is commonly known as MIVAN construction, named for the construction company that first produced this aluminium formwork. This is now common in large residential towers and mass-housing in Tier 1 cities of India.

RCC frame + Masonry

This can be considered the most common construction technology in India. Here, a Reinforced Cement Concrete (RCC) frame consisting of columns, beams, and slabs forms the load-carrying structure, while brick / block masonry walls act mainly as partitions or infill walls and do not carry major structural loads.

Load bearing

In this type of construction, masonry walls themselves carry all vertical loads from slabs and roof and transfer them to the foundation. It is used primarily in low-rise buildings.

SEISMIC ZONES

India is divided into four main seismic zones for design and planning under IS 1893 (Part 1). Zone V is seismically the most active region, while zone II is the least.

- Zone II: Low damage risk zone. Bengaluru and Hyderabad are located here.
- Zone III: Moderate damage risk zone. Mumbai, Pune and Kochi are located here.
- Zone IV: High damage risk zone. Not applicable in this study.
- Zone III: Very high damage risk zone. Not applicable in this study.

PARKING TYPE

The type of parking designed to take care of the parking requirement is also expected to impact material quantities, especially that of concrete and steel. Parking type has been categorised into the following:

Basement parking
Parking is provided below ground level, one or more floors under the building footprint or beyond, accessed via a ramp.

Podium parking
Parking levels are built on a raised platform or podium, typically just above the ground floor or up to first/second floor, integrated with the building's footprint. The residential towers or main building sit on top of this podium.

Stilt parking
The ground floor of the building is an open or semi-open space supported on columns or stilts, and this space is used for parking. The residential units start above this stilt level.

Open parking
Parking is provided at ground level without major structural enclosure or shelter.

NOMENCLATURE OF BUILDINGS IN THIS STUDY

Parameter codes

Building height	Code
Low-rise	L
Mid-rise	M
High-rise	H

Construction technology	Code
Monolithic concrete	MC
RCC frame + masonry	RF
Load bearing	LB

Seismic zone	Code
Zone II	Z2
Zone III	Z3
Zone IV	Z4
Zone V	Z5
Zone VI	Z6

Parking type	Code
Basement	B
Podium	P
Stilt	S
Open	O

Nomenclature format
Seismic zone – Building height – Construction technology – Parking

For e.g. Z2-H-MC-B for a high-rise monolithic concrete building in Zone II with basement parking.

DATA COLLECTION FROM THE BUILDINGS

MATERIAL QUANTITIES

Quantities of materials used in constructing the substructure, envelope and interiors (see section “Study focus”) were collected in the form of Bill of Quantities (BoQs). In a few cases, these quantities were shared separately instead of the entire BoQ.

It was found that quantities of materials like concrete, steel and flooring from the BoQ can be directly used for calculating their corresponding emissions. This is because the units used to quantify them in the BoQ is the same as the functional unit used for their emissions. For e.g. emissions for steel is denoted in kg CO_2e / ton of steel and building BoQ also record steel quantity in tons of steel.

However, for certain materials further computation is required. For e.g. BoQs record quantity of wall masonry as cubic metre or square metre of wall built, which would include both the walling blocks used as well as the mortar. Another example is that of windows, where the BoQ contains square metre of windows and not separate quantities for window frame (aluminium, uPVC or timber) and glass. In such cases, further computation is required based on further specifications, and in their absence, assumptions and thumb rules.

MATERIAL / PRODUCT SPECIFICATIONS

The BoQ generally contains enough specification of each material or product to enable the appropriate carbon emission calculation. In case of concrete, further information about their mix ratio is required. For e.g. the BoQ may mention the quantity of M30 concrete used, but information on its specific composition (amount of OPC, any SCMs used like GGBS or fly ash, coarse and fine aggregate) were also collected. If unavailable, standard mix ratios were considered. However, here too information about any percentage replacement of OPC with SCMs was required.

Another material where further specification was asked for, if available, is the recycled content of steel. This is not well recorded by the projects. Generally, carbon emission factor of secondary steel (direct reduced iron + induction furnace) has been considered, except where further specification was given.

MATERIAL SOURCES (LOCATION)

This information was taken from the buildings in two ways:

- in the form of sourcing locations, usually given for Ready-mix Concrete (RMC), walling blocks and windows.
- Brand names, which can indicate where the product has been manufactured. For e.g. vitrified tiles.

This is required to compute the emissions in the A4 stage (transport to site).

FUEL USED ON-SITE DURING CONSTRUCTION

Energy usage data for on-site activities has been gathered from participating buildings to calculate A5 (construction) emissions. This data includes the quantities of various fuels employed, mainly grid electricity and diesel. This has been in the form of total electrical units consumed and total diesel quantity (in litres) throughout the construction process.

CALCULATING UPFRONT EMBODIED CARBON

PRODUCT STAGE (A1-A3)

A1-A3 emissions = **Material quantity** × **Global Warming Potential (GWP) or Carbon emission factor (CEF) of material**

The CEF of all materials and products were collected using the following routes (in descending order of preference):

- If a valid Indian EPD (Environmental Product Declaration) of the product brand used in the construction is available, the emission factor (A1–A3) is directly derived from the EPD.

- If an EPD is not available for the product brand used, but an Indian EPD of another brand using the same product composition and manufacturing process is available, then this EPD is used to derive the emission factor.

- If no Indian EPD is available, the emission factor is calculated by obtaining plant-based information from manufacturers of the product. This plant-based information encompasses raw materials used (A1), the procurement process of raw materials (transport - A2), and energy and fuel consumption at the manufacturing plant (A3).

  In this method, A1 emissions information was sourced from research papers, individual raw material EPDs (if available), and a few necessary assumptions. For A2 emissions, India-based vehicle emission factors are employed. A3 emissions were calculated using standards or latest India-specific emission factors for electricity and various other fuels.

- In the absence of information through the above routes, an International EPD is utilized to derive the emission factor. The figures obtained from these EPDs were deliberated with industry experts and utilized for this study after confirming their alignment with the manufacturing process used in India.

Some of the material CEFs used in this study are in Annexure I.

TRANSPORT-TO AND FROM SITE- STAGE (A4)

$$\text{A4 emissions} = \frac{\text{Material quantity}}{\text{Payload capacity of transport mode}} \times \text{Distance to site} \times \text{Emission factor of transport mode}$$

Emission factor of vehicle types[13]

Category	Payload capacity (tonnes)	Emission factor ($kgCO_2e$ / km)
MDV (Medium duty vehicles)	Less than 12	0.5928
HDV (Heavy duty vehicles)	More than 12	0.7375

CONSTRUCTION AND INSTALLATION STAGE (A5)

$$\text{A5 emissions} = \text{Fuel quantity} \times \text{Emission factor of fuel}$$

Emission factor of fuels used on site for construction and installation

Energy input (type of fuel)	Functional unit (FU)	Emission factor ($kgCO_2e$ / FU)
HSD (High-speed Diesel)[14]	Litre	2.64
Electricity[15]	kWh	1.1

REPORTING AND CONTRIBUTION OF UPFRONT EMBODIED CARBON STAGES (A1-A5)

Of the 26 buildings assessed, only 12 provided data for A4 (transport to site) and A5 (construction and installation) life-cycle stages. The remaining projects provided data for A1–A3 (product stage) only.

Where A4 and A5 data were available, A1–A3 consistently accounted for 90–97% of upfront embodied carbon. **Given the limited availability of data for A4 and A5 emissions across the sample, and the clear dominance of A1–A3 emissions, all subsequent analyses presented in section "Key Findings" focus on A1–A3 emissions.**

NORMALIZING FOR COMPARISON

BUILT-UP AREA (BUA)

Sum of the covered areas of all floors of a building, other than the roof, and areas covered by external walls and parapet on these floors.

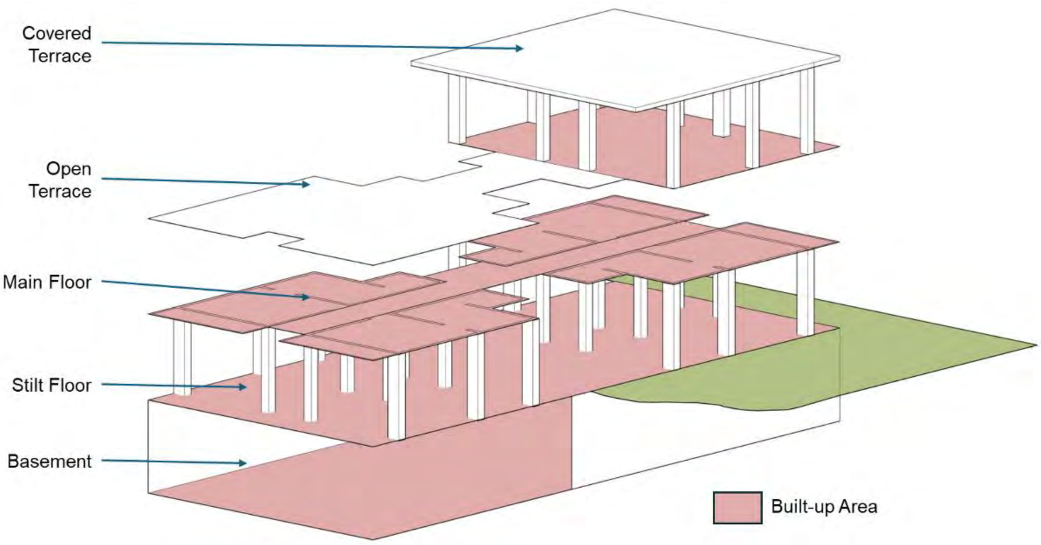


Figure 3: Graphic showing built-up area (BUA)

Section 3: Key findings of the study

3.1 Embodied carbon intensity (A1 – A3): Base case
3.2 Embodied carbon intensity: Low-carbon material case
3.3 Embodied carbon intensity and height
3.4 Contribution of different products
3.5 Concrete and steel use intensity
3.6 Contribution of substructure and superstructure

3.1 Embodied carbon intensity (A1-A3): Base Case

The calculations under the base case were done as per reported data from the builders on both the qualities and the specifications of the building materials.

The 26 buildings assessed are constructed using one of the following construction technologies:

- Monolithic concrete construction
- RCC framed and masonry construction
- Hybrid construction: Basement and pile foundation below plinth, and load-bearing above plinth level

As there are only 2 projects with hybrid construction, they were also classified under RCC frame + masonry construction.

Material variation in these projects include:

- Concrete (various grades): Use of supplementary cementitious material (SCMs) varies from 100% Ordinary Portland Cement (OPC) based concrete to 50% OPC replacement with Ground Granulated Blast Furnace Slag (GGBS).
- Cement used for mortar, plaster and other purposes: Ordinary Portland Cement (OPC) and Portland Pozzolana Cement (PPC)
- Steel: Generally considered with 40% recycled steel content. Where mentioned steel with 0%, 20% and 75% recycled steel content considered.
- Masonry blocks: Solid concrete blocks, Autoclaved Aerated Concrete (AAC) blocks, hollow clay fired (Porotherm) blocks, Compressed Stabilised Earth blocks (CSEB), clay fired Hurdi blocks, Flyash bricks
- Window frame: UPVC, Aluminium, Timber
- Glass: Single glass, Double Glass Unit (DGU)
- Flooring: Vitrified tile, Ceramic tile, Timber flooring, Granite, Marble, Kota, Cuddapah, Cement-based tile, Vacuum Dewatered Flooring (VDF)

EMBODIED CARBON (A1-A3) INTENSITY NORMALIZED OVER BUILT-UP AREA (BASE CASE)

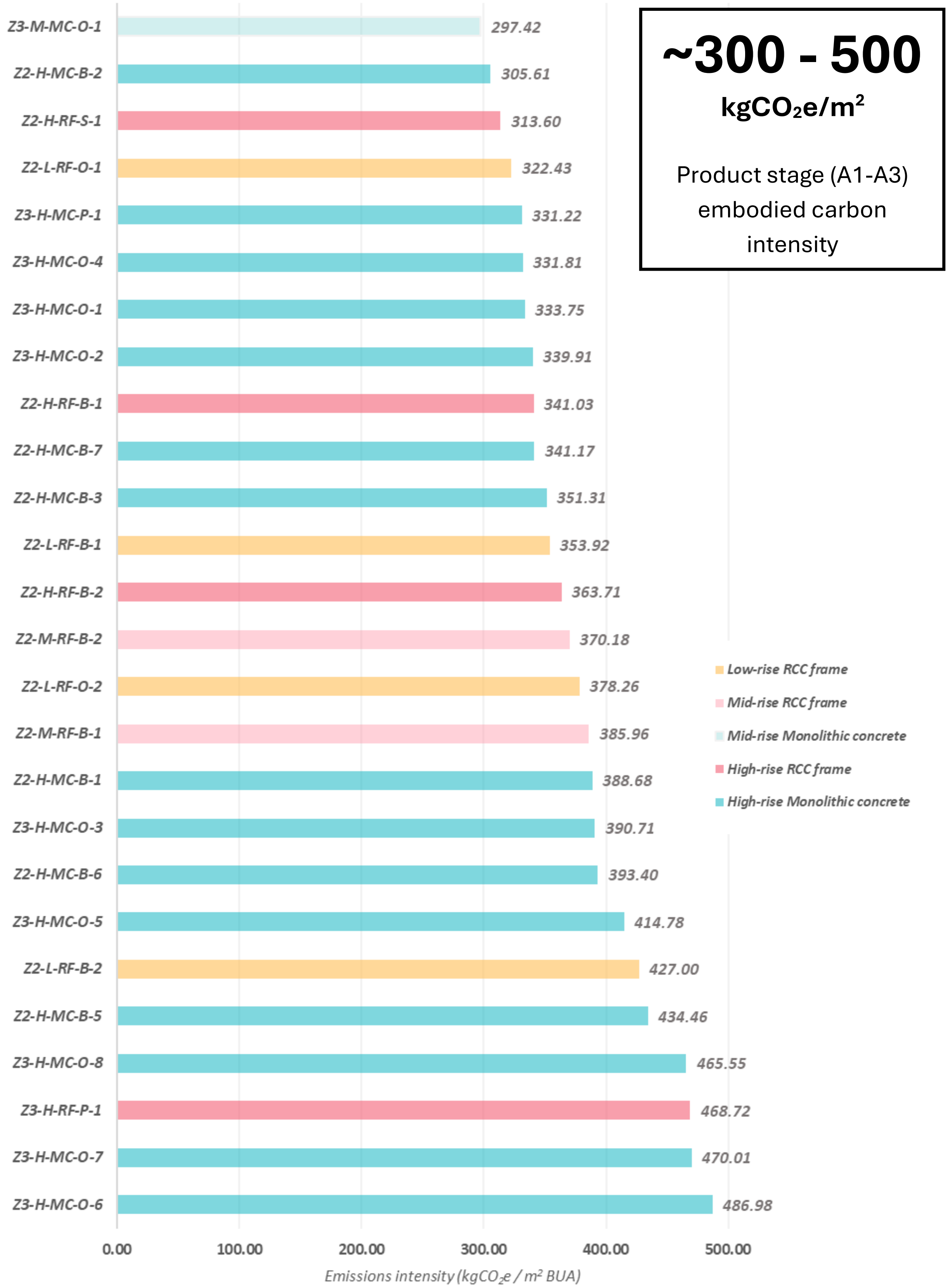


Figure 4: Embodied carbon intensity (base case)

EMBODIED CARBON (A1-A3) INTENSITY: 25TH, 50TH (MEDIAN) AND 75TH PERCENTILES (BASE CASE)

The median embodied carbon intensity (A1-A3) of the assessed building samples is 366.9 $kgCO_2e/m^2$ BUA. Table 1 shows the 25th, 50th (median) and 75th percentiles of the embodied carbon intensities of various sub-categories among the 26 building samples (also see Figure 5).

The median (50th percentile) indicates the typical project within the dataset, while the 25th and 75th percentiles define the interquartile range and capture the spread of the central 50% of buildings. This approach reduces the influence of extreme values and provides clearer thresholds for evaluating relative performance.

Table 1: 25th, 50th (median) and 75th percentiles of all 26 buildings and sub-categories (base case)

		Embodied carbon intensity ($kgCO_2e/m^2$ BUA)		
		25th percentile	50th percentile (Median)	75th percentile
All samples (26 buildings)		334	367	415
Seismic zone	Zone 2 (15 buildings)	341	364	387
	Zone 3 (11 buildings)	333	391	467
Construction technology	Monolithic concrete construction (16 buildings)	333	370	425
	RCC frame + masonry / Hybrid (10 buildings)	341	367	386
Height	High-rise (19 buildings)	337	364	425

367

$kgCO_2e/m^2$

Median (50th percentile) embodied carbon intensity of all 26 buildings (Base case)

EMBODIED CARBON (A1-A3) INTENSITY: 25TH, 50TH (MEDIAN) AND 75TH PERCENTILES

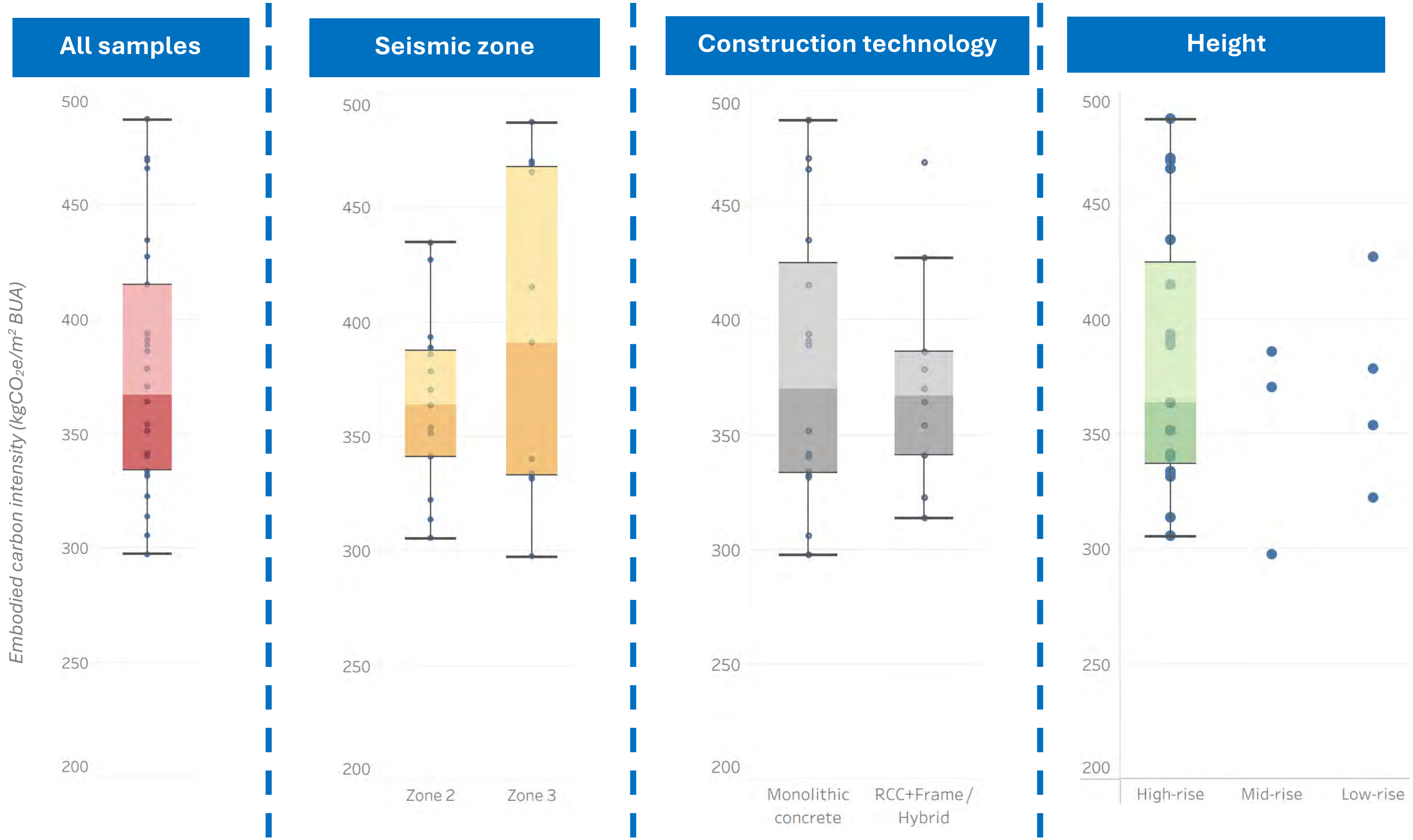


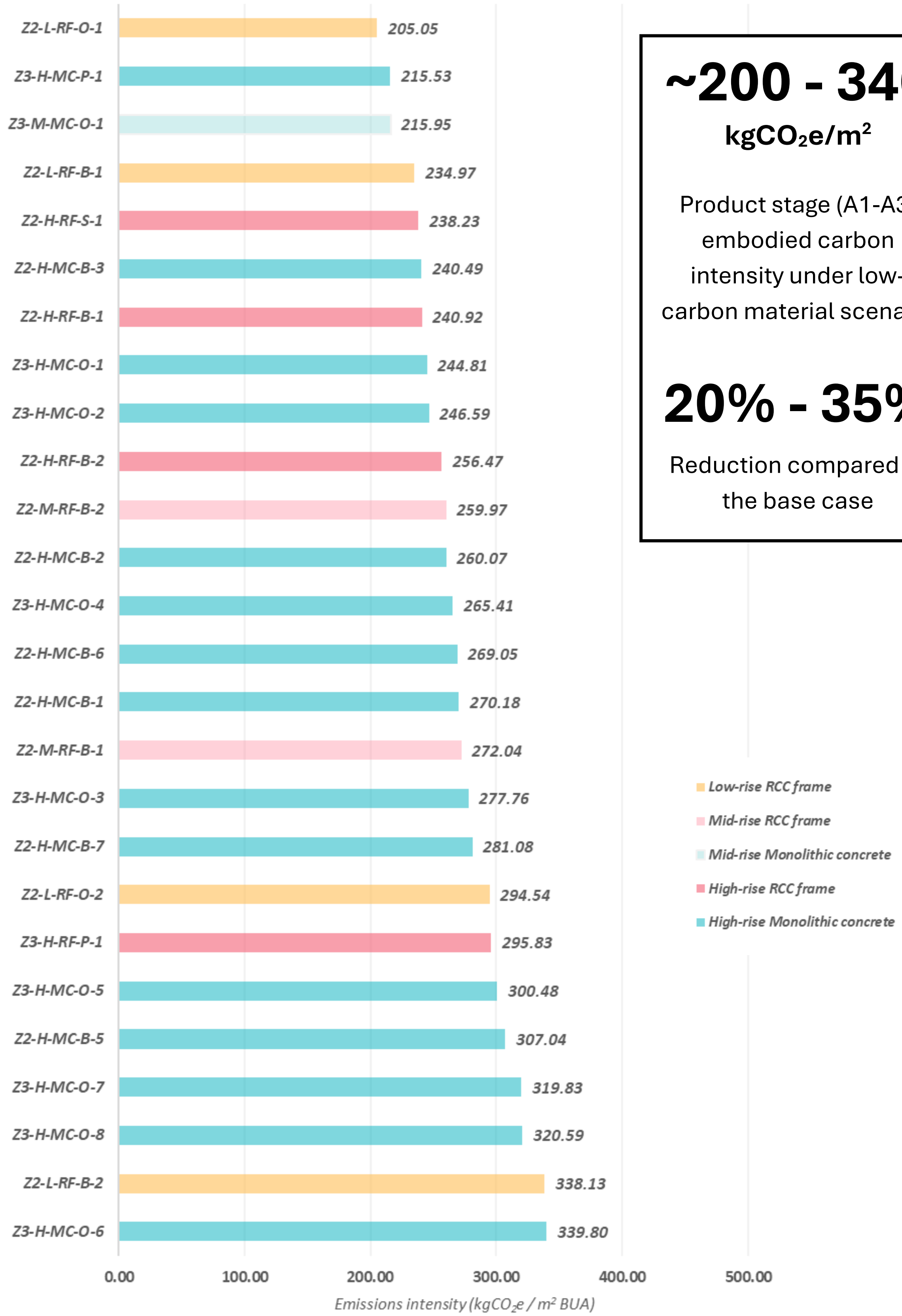
Figure 5: Embodied carbon intensity- 25th, 50th and 75th percentiles (Base case)

3.2 Embodied carbon intensity: Low-carbon material case

The embodied carbon calculations for the baseline case showed that three construction materials i.e. concrete, steel and cement are the largest contributors. Keeping this in mind, another set of embodied carbon calculations were done for a hypothetical low-carbon material case. Here it was assumed that all the 26 projects are using low-carbon concrete, cement and steel options, available in the Indian market. Under a low-emission material scenario, the following was considered for the different materials.

- Concrete (various grades): All grades of concrete used in all projects have 50% OPC replacement with Ground Granulated Blast Furnace Slag (GGBS).
- Cement used for mortar, plaster and other purposes: Portland Pozzolana Cement (PPC)
- Steel: 5-star steel as per the Green Steel Taxonomy, i.e. emissions of 1.6 $kgCO_2e/kg$ of finished steel
- Masonry blocks: No change
- Window frame: No change
- Glass: No change
- Flooring: No change

EMBODIED CARBON (A1-A3) INTENSITY (LOW-CARBON MATERIAL CASE)



~200 - 340

$kgCO_2e/m^2$

Product stage (A1-A3) embodied carbon intensity under low-carbon material scenario

20% - 35%

Reduction compared to the base case

Figure 6: Embodied carbon intensity (Low-carbon material case)

EMBODIED CARBON (A1-A3) INTENSITY UNDER LOW-CARBON MATERIAL CASE: 25TH, 50TH (MEDIAN) AND 75TH PERCENTILES

In the low-carbon material scenario the median embodied carbon intensity (A1-A3) of the assessed building samples is 267.2 $kgCO_2e/m^2$ BUA, a reduction of nearly 27%. Table 2 shows the 25th, 50th (median) and 75th percentiles of the embodied carbon intensities of various sub-categories among the 26 building samples, under a low-carbon material scenario (also see Figure 7).

Table 2: 25th, 50th (median) and 75th percentiles of all 26 buildings and sub-categories (Low-carbon material case)

		Embodied carbon intensity ($kgCO_2e/m^2$ BUA)		
		25th percentile	**50th percentile (Median)**	**75th percentile**
All samples (26 buildings)		241	267	296
Seismic zone	**Zone 2 (15 buildings)**	241	260	277
	Zone 3 (11 buildings)	246	278	310
Construction technology	**Monolithic concrete construction (16 buildings)**	246	270	304
	RCC frame + masonry / Hybrid (10 buildings)	238	258	295
Height	**High-rise (19 buildings)**	246	269	298

267

$kgCO_2e/m^2$

Median (50th percentile) embodied carbon intensity of all 26 buildings in a low-carbon material scenario

27% reduction compared to base case

EMBODIED CARBON (A1-A3) INTENSITY UNDER LOW-CARBON MATERIAL SCENARIO: 25TH, 50TH (MEDIAN) AND 75TH PERCENTILES

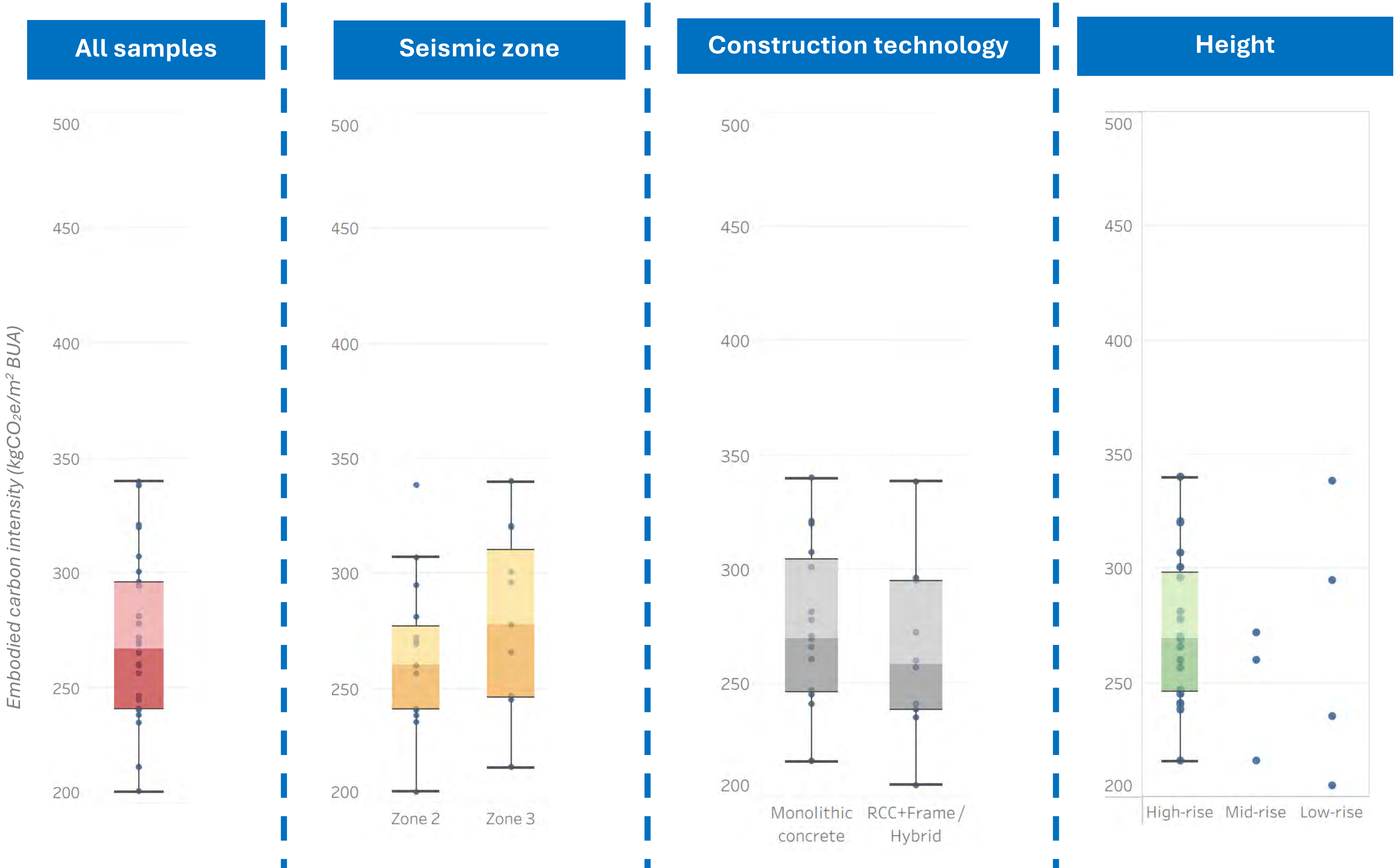


Figure 7: Embodied carbon intensity- 25th, 50th and 75th percentiles (Low-carbon material case

3.3 Embodied carbon intensity and height

The co-relation between height and embodied carbon intensity, within the current sample, is weak to moderately positive (Figure 8). While the tallest buildings in the sample (36-45 storeys) tend to exhibit higher embodied carbon intensities, there is substantial overlap across mid-rise and lower-rise projects. Buildings up to 20 storeys display a wide range of intensities.

The dispersed embodied carbon intensities at comparable heights indicates the strong influence of project-specific factors like foundation requirements, presence of basements, material use intensity as well as material emission factors. For e.g.

- 9 of the 16 monolithic concrete buildings do not have any parking space (basement, stilt or podium) with it, 1 has podium parking, and the rest have one or more basements.
- 1 of the 6 high-rise and mid-rise RCC frame + masonry buildings has pile foundations of nearly 28m depth.
- 2 of the 4 low-rise RCC frame + masonry / hybrid buildings have basement parking as well as deep pile foundation.

EMBODIED CARBON INTENSITY AND HEIGHT

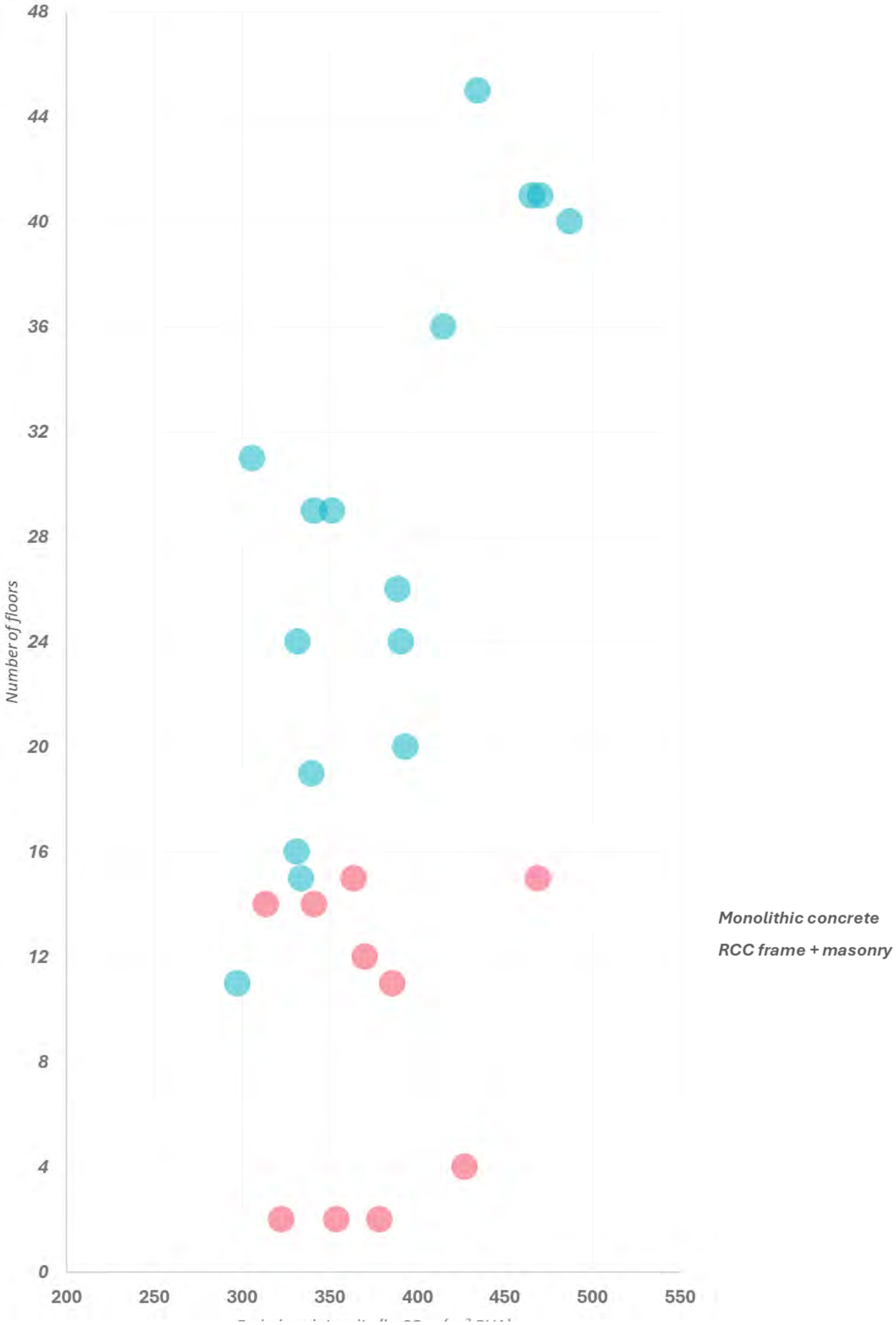


Figure 8: Embodied carbon intensity and height

3.4 Contribution of different products

CONCRETE AND STEEL

Concrete and steel contributed the largest share of embodied carbon, ranging from 60% to 91% (Figure 9 and Figure 10). In buildings with monolithic concrete construction, embodied carbon from concrete ranged from 35% to 52%, and from steel ranged from 28% to 51%. In RCC frame + masonry construction, embodied carbon from concrete ranged from 29% to 43%, and from steel ranged from 27% to 51%.

MASONRY

Emissions from masonry contribute a fair share in RCC frame + masonry construction, ranging from 4% to 16%. Two of these ten buildings use Porotherm blocks (hollow fired clay bricks) as the walling material and show embodied carbon share from masonry below 5%.

In monolithic concrete construction, masonry contributes up to 5% of the embodied carbon.

REMAINING EMISSIONS

Emissions from flooring and cladding, doors and windows, and plaster make up the remaining share of embodied carbon. Emission share from doors and windows are seen to be higher when aluminium frames have been used. While aluminium frames are durable and last longer, their contribution to upfront carbon emissions turn out to be significant.

PRODUCT SHARE IN MONOLITHIC CONCRETE BUILDINGS

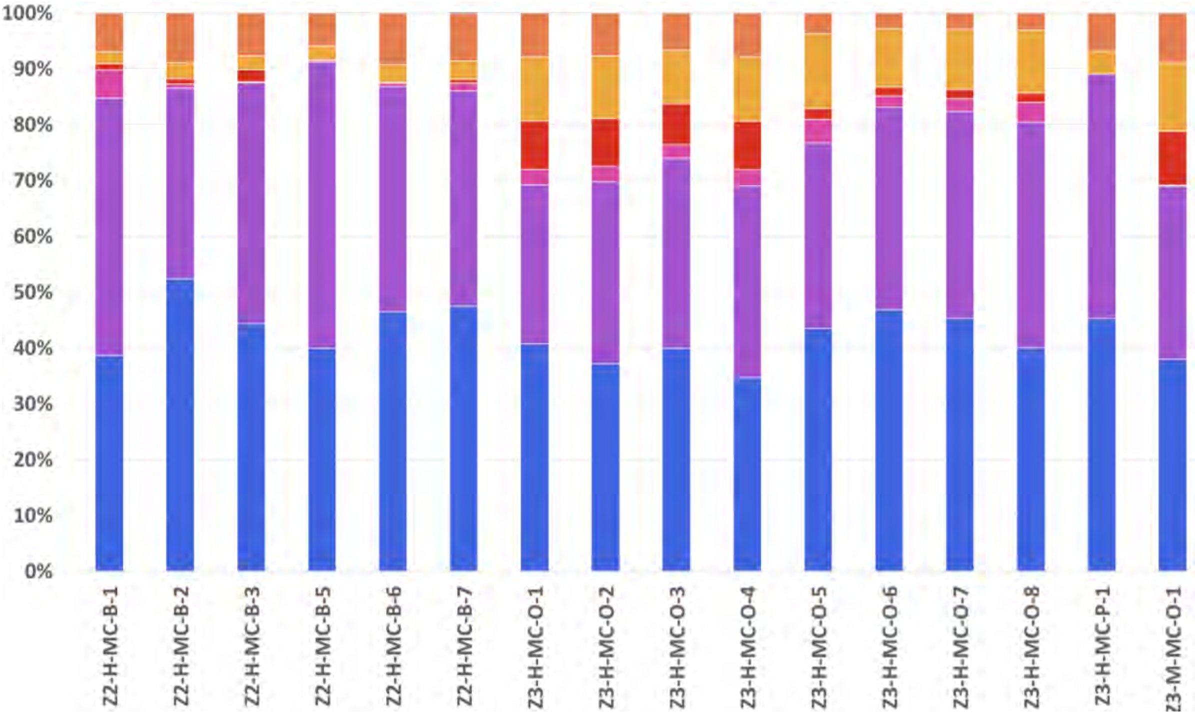


Figure 9: Product share (%) in monolithic concrete buildings

PRODUCT SHARE IN RCC FRAME + MASONRY BUILDINGS

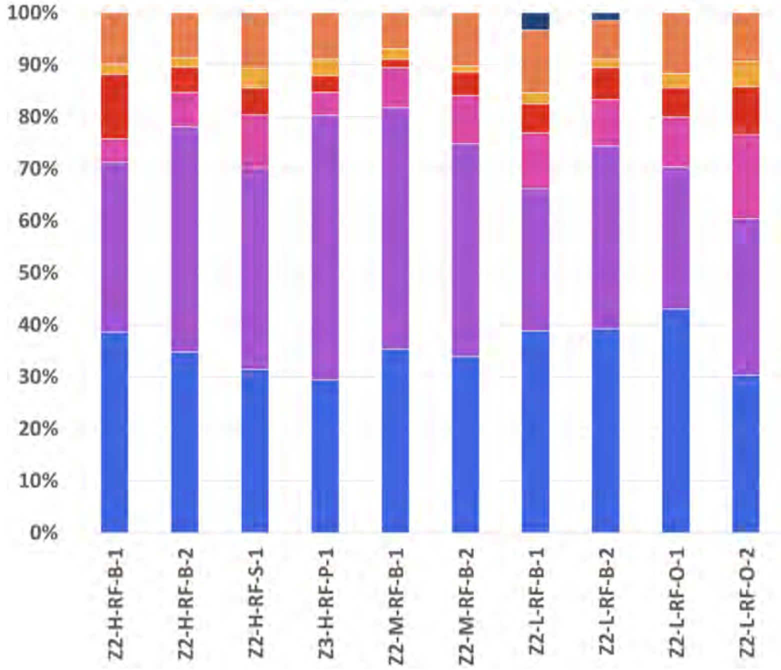


Figure 10: Product share (%) in RCC frame + masonry buildings

3.5 Concrete and steel use intensity

Within the sample buildings, concrete use intensity (in m^3/m^2 BUA) is higher in high-rise buildings. However, steel use intensity (in kg/m^2 BUA) is highly dispersed. This can be attributed to structural design, foundation requirements and presence of basements (See Figure 11 and Figure 12).

Table 3 shows the range of concrete and steel use intensities in the sampled buildings, along with the concrete and steel use intensities given in the report "Comparative Evaluation of Embodied Carbon of High-rise & Low-rise Buildings in India" published by Global Cement and Concrete Association (GCCA) India in late 2025[b]. The maximum concrete and steel use intensities calculated in the present study are comparable to the designed intensities of the GCCA report.

Table 3: Concrete and steel use intensities of study sample and GCCA report

Height category	Present study		GCCA 2025 report	
	Concrete use intensity (m^3/m^2)	**Steel use intensity (kg/m^2)**	**Concrete use intensity (m^3/m^2)**	**Steel use intensity (kg/m^2)**
High-rise	0.37 – 0.73	34 – 67 *(Outlier 85 kg/m^2 BUA for building with deep pile foundation)*	0.76 – 0.78	71.5 – 80.3
Mid-rise	0.39 – 0.47	33 – 64		
Low-rise	0.36 – 0.44	31 – 62	0.33 – 0.45	30.5 – 50.4

[b] The GCCA-India report provides a comparative assessment of embodied carbon from a typical high-rise and low-rise building, considering the current design and construction practice followed in India. For the high-rise building, a typical G+34 storey building located in a Zone 3 city was considered, with 2 flats on each floor, four lifts, two staircases and two mechanical parking towers. This building is a reinforced concrete (RC) framed structure with columns/shear walls. 12 alternatives were prepared for the comparative evaluation of embodied carbon in high-rise buildings.

For the low-rise building, a typical G+3 storey building was considered. Conventional RC framing system with/without shear walls were considered, and four walling material options were considered- fired clay bricks, AAC blocks, EPS sandwich panels and fly ash bricks. Additionally, the use of three types of cements – Portland Pozzolana Cement (PPC), Portland Slag cement (PSC) and the Ordinary Portland cement (OPC) were considered for the concrete. 24 alternatives were prepared for the comparative evaluation of embodied carbon in low-rise buildings.

CONCRETE USE INTENSITY IN SAMPLE BUILDINGS

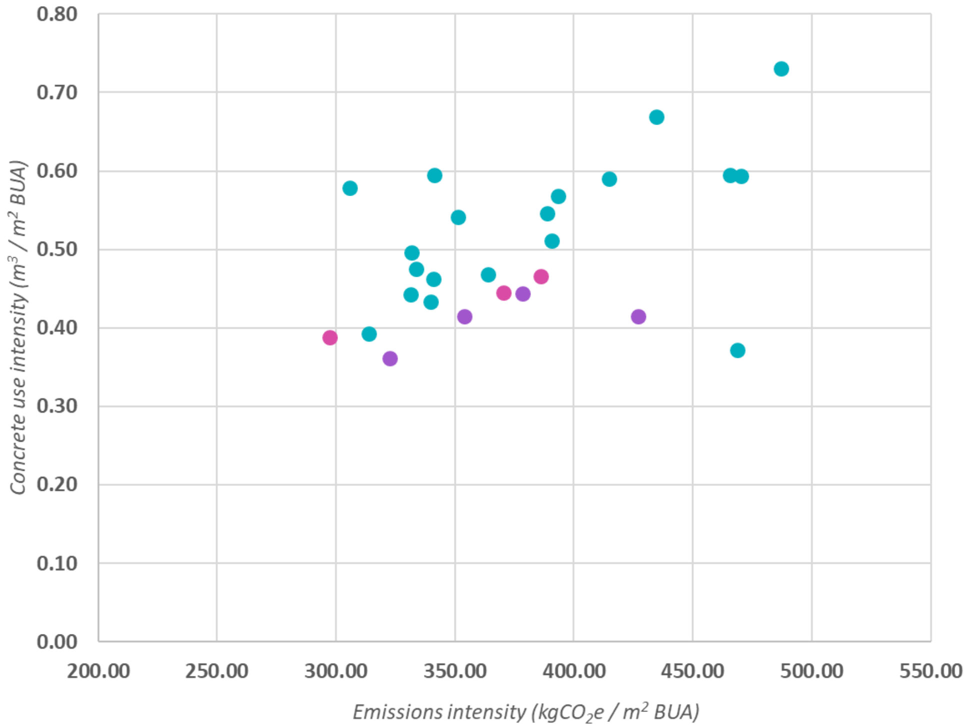


Figure 11: Concrete use intensity in sample buildings

STEEL USE INTENSITY IN SAMPLE BUILDINGS

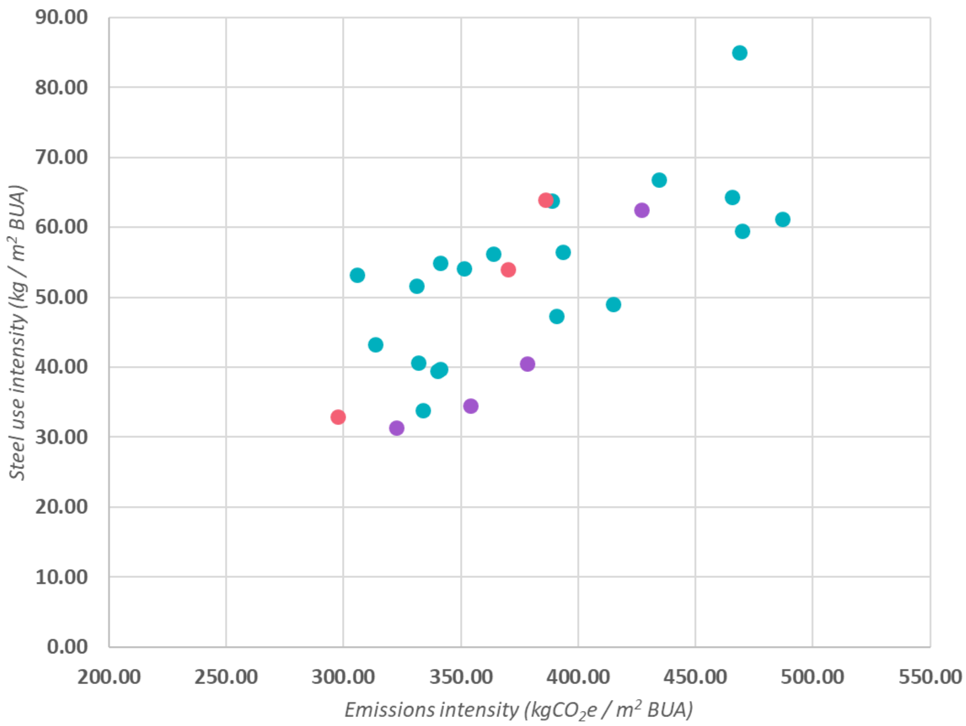


Figure 12: Steel use intensity in sample buildings

3.6 Contribution of substructure and superstructure

Material quantities categorised as per substructure, and superstructure (including envelope and interiors) were provided for 13 out of the 26 assessed buildings. 3 of these buildings have podium or stilt parking and the remaining 10 have basement parking. The contribution of the substructure to the embodied carbon is markedly lower (<20%) in the buildings without basement parking (Figure 13. More buildings with disaggregated material data and differing parking and foundation types need to be studied for better understanding.

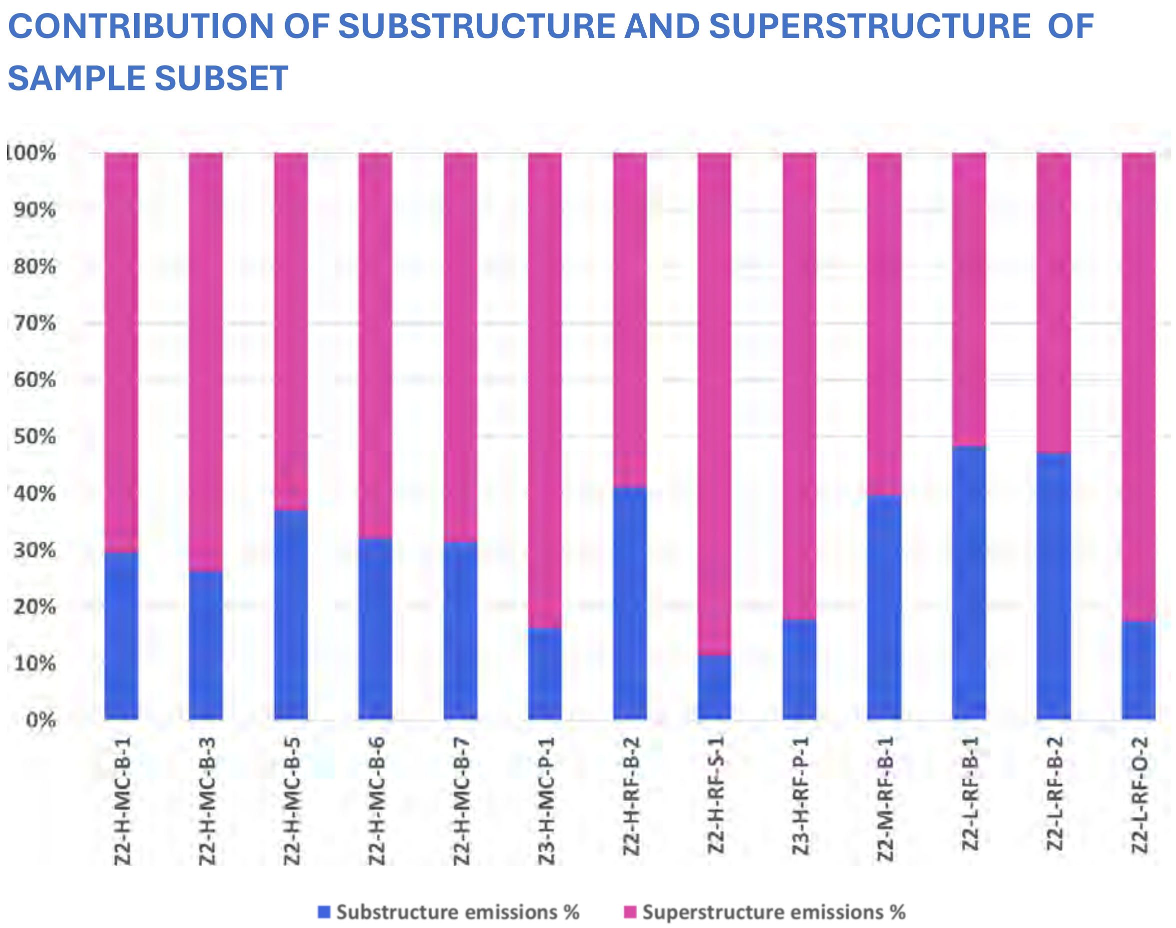


Figure 13: Share of substructure and superstructure (%)

Section 4: From findings to action

4.1 India's proposed policy intervention for embodied carbon
4.2 Developing LCA methodology, reporting and future compliance
4.3 Enabling on-ground embodied carbon reduction through regional roadmaps
4.4 Awareness and capacity building

4.1 India’s proposed policy intervention for embodied carbon

NITI Aayog, the apex public policy think-tank of the Government of India, published the report “Scenarios Towards Viksit Bharat and Net Zero - Sectoral Insights: Buildings (Vol. 5)” in February 2026. Among other aspects, the report also proposes broad policy interventions related to embodied carbon which is summarised in below.

PROPOSED POLICY INTERVENTIONS: EMBODIED CARBON DISCLOSURES, BENCHMARKS AND TARGETS

Short term (by 2030)

- Standard Life Cycle Assessment (LCA) methodology and rules for construction materials/ products and building-level LCA
- Phased introduction of EPD requirements for building materials and products.
- Approved independent accreditation bodies or individual verifiers for accrediting EPDs
- Online public register of accredited EPDs, readily searchable. National database of generic material / product embodied carbon values made available, to be used in absence of product specific EPDs.
- EPD data used for benchmarking and assigning green labels for low-carbon products.
- Green-labelled products included in the public sector schedule of rates.
- Public sector (> defined threshold) and commercial buildings falling under ECSBC disclose embodied carbon. Online portal for reporting and data collection that enables data to be benchmarked and used for future target setting

Medium term (by 2035)

- Embodied carbon reduction targets for large public sector (> defined threshold) and commercial buildings under ECSBC.

Long term (beyond 2035)

- Tighter embodied carbon reduction targets for all public sector and commercial projects falling under ECSBC
- Embodied carbon reduction targets for small commercial and residential buildings.

PROPOSED POLICY INTERVENTIONS: COMPLEMENTARY INDUSTRIAL SECTOR POLICIES

Short term (by 2030)

- Visibility of medium to long term GHG emission reduction targets under Carbon Credit Trading Scheme (CCTS) for key building materials (cement, steel, metals, bricks, glass) to drive investment and innovation
- Policies to improve supply of waste streams as raw materials, such as penalties and/or incentives to divert agricultural and industrial waste from being burned or going to landfill

Medium term (by 2035)

- Perform, Achieve and Trade (PAT) remit progressively expanded to cover other key building materials and products.

Long term (beyond 2035)

- Perform, Achieve and Trade (PAT) remit progressively expanded to cover other key building materials and products.

PROPOSED POLICY INTERVENTIONS: COMMERCIALISATION SUPPORT FOR GREEN MATERIALS AND ENERGY EFFICIENT PRODUCTS

Short term (by 2030)

- Targeted grants and other financial incentives for R&D, commercialization as well as domestic manufacturing of green materials, energy efficient equipment and critical supply chain components. This includes specific policies to encourage academic and research institutions to proactively collaborate with
- Provide support for commercialisation through RESCO/ESCO models, targeting low energy and low-cost cooling, low-carbon masonry, prefabricated systems, high-performance envelopes

Medium term (by 2035)

- Track market progress, review and refine policies to support commercialisation.

Long term (beyond 2035)

- Track market progress, review and refine policies to support commercialisation.

Based on these proposed policy interventions as well as the experience of conducting the LCA for the 26 buildings in this study, the following priority interventions are proposed:

Developing LCA methodology, reporting and future compliance

- LCA methodology for buildings in India
- India-specific carbon intensities or GWP of building materials
- Embodied carbon reporting framework for disclosure and future compliance
- Establishing baselines and benchmarks

Enabling on-ground embodied carbon reduction through regional roadmaps

- Embodied carbon benchmarks as compliance instruments
- Building material procurement policies
- Supply-side material transition strategy
- Circular construction policies prioritised where needed

Awareness and capacity building

Each of these interventions are discussed in the following chapters.

4.2 Developing LCA methodology, reporting and future compliance

LCA METHODOLOGY FOR BUILDINGS IN INDIA

For building-level LCA, there are established international standards, the most widely followed being ISO 14040 / 14044 and EN 15978. ISO 14044 is a general LCA framework applicable to products, processes and services. EN 15978 specifies LCA for buildings.

Embodied carbon reporting frameworks and benchmarks in other countries broadly follow the above standards, while adapting it to define the scope, system boundaries, data requirements and reporting framework to their contexts. Country-specific embodied carbon calculation methodology involves making the following decisions:

- LCA scope
- Building physical scope
- Functional unit or Normalisation metric used
- Carbon intensities or GWP values of building materials and products

LCA SCOPE

All existing embodied carbon baselines and benchmarks, at minimum, cover LCA stages A1-A5. Many European benchmarks also include B1-B5 and C1-C4 stages. Indian embodied carbon studies have concentrated on A1-A3 stages, with some including A4 and A5 stages.

RECOMMENDATION: It has been generally agreed in several expert consultations[c] in India that A1–A3 should be adopted as the initial scope as it accounts for the largest share of embodied emissions and has relatively strong data availability. Data for A4 (transportation of materials from plant to site) and A5 (construction and installation) is not always recorded and needs better documentation protocols/ formats.

In future, the additional LCA stages can be included in the following suggested order of priority:

- C1-C4 stages (End-of-Life): These stages account for emissions during demolition, waste transport, processing, and disposal and are important for circular-economy and material-reuse considerations. The starting point could be developing detailed

[c] *This includes a roundtable organized by Rocky Mountain Institute (RMI) India as well as individual expert meetings conducted during this study.*

end-of-life scenarios and modeling them, complimented by actual improvement in material recovery and reuse.

- B1-B5 stages (Use): These stages account for embodied emissions during the use phase of the building. Here, valid and realistic assumptions on use, repair, replacement, renovation etc. need to be developed for different building elements.

BUILDING PHYSICAL SCOPE

Substructure and envelope are included in all existing baselines and benchmarks, with interiors also included in most of them. Mechanical Electrical and Plumbing (MEP) is included in the European benchmarks that were referred for this study, one of which also specified inclusion of emissions associated with refrigerant leakage. Site materials (e.g. landscape and external site works) was also included in the ILFI embodied carbon threshold.

Most Indian studies have limited the physical scope to sub-structure, envelope and, in few cases, flooring. MEP has also been included in a small number of studies (E.g. studies by Lodha[16] and CARBSE[17]).

RECOMMENDATION: Expert consultations have suggested including substructure and envelope, as they account for the highest emission share and include the main high-emission impact materials. “Envelope” includes the above ground structural elements (columns, beams, floor slabs, roof slab, structural walls), external walls, and external doors and windows. Internal partitions and interior finishes can vary significantly even within building typologies, due to the market segment, user preference etc. and hence can be excluded initially.

Within the residential building category, it was found that it is difficult to differentiate between external and internal walls from the BoQ, particularly for monolithic concrete buildings. Hence all walling quantities may be considered.

MEP quantities may be included in the physical scope for building typologies that are heavy on services and systems, for e.g. hospitals, hotels and some office types. As the MEP elements are also invariably replaced once or twice during the building life cycle, it will also strengthen the understanding and baselining of the “Use” stage (B1-B5).

NORMALISATION AREA

Different area metrics are used to normalise embodied carbon in the existing benchmarks. These can be broadly categorised into the following three categories:

- Gross Floor Area (GFA): GFA is similar to built-up area as used in India, i.e. it is sum of all areas on all floors of a building included within the outside faces of its exterior walls, including all vertical penetration areas, areas for circulation, and shaft areas that connect one floor to another.

  Different benchmarks have used GFA as per the definition above (e.g. the Danish BR25) or with some subtractions.

- Gross Internal Area (GIA): Building carbon benchmarks in the UK use GIA as the normalisation area. GIA is the area of a building measured to the internal face of the perimeter walls at each floor level, excluding open-sided balconies and canopies.

- Usable Floor Area: The French RE2020 uses Usable Floor Area as the normalisation metric, which is similar to the carpet area used in India. Usable Floor Area is defined as the built floor area with the following exclusions:
  - area occupied by walls, partitions, steps and stairwells, shafts, door and window recesses, common areas and other outbuildings,
  - parts of premises with a ceiling height of less than 1.80 m,
  - roof terraces, balconies, unheated verandas, unenclosed areas located on the ground floor or upper levels, and
  - vehicle parking areas.

All Indian studies have used Built-Up Area (BUA) as the normalisation metric.

RECOMMENDATION: In expert consultations in India, built-up area (including enclosed parking and shared amenities) is recommended to be used as the normalisation area for its consistent definition and reporting in basic building documents. This, along with the ubiquity of enclosed parking for most building typologies in urban India, makes BUA the most feasible normalisation area.

CARBON INTENSITIES OR GWP VALUES OF BUILDING MATERIALS AND PRODUCTS

Existing benchmarks specify the permissible sources of carbon intensities or GWP of building materials and products. Some examples are shown in Table 4.

RECOMMENDATIONS: A database of permissible material GWPs is recommended. This means:

- National and sub-national datasets, at least for the key materials, must be endorsed or developed. This also contributes to documenting carbon emissions and decarbonisation efforts in those material industries.

- A consolidated national database is developed, that would be a repository of national and sub-national material GWP datasets, all available India-specific EPDs, and permissible GWP values for any remaining materials.

The issue of material GWP is discussed further in the following section.

Table 4: Material GWP databases or sources allowed for existing benchmarks.

<table>
<tr><th>Benchmark</th><th>Type of benchmark</th><th>Material GWP sources allowed</th></tr>
<tr><td>RE2020 (France)</td><td>Mandatory regulation with embodied carbon limits</td><td>INIES database, which includes product-specific EPDs and generic factors where product EPDs don’t exist. Other databases are explicitly not allowed.</td></tr>
<tr><td>BNB (Germany)</td><td>Regulation, which assigns a certification score. Mandatory for federal buildings</td><td>ÖKOBAUDAT database, which contains product-specific datasets and generic datasets.</td></tr>
<tr><td>BENG / MPG (Netherlands)</td><td>Mandatory regulation with limit on a numerical performance score that also includes embodied carbon.</td><td>Nationale Milieu database (NMD), within which Category 1 data (product-specific EPDs) is incentivised. Category 2 (sector average) and Category 3 (generic data) are also available.</td></tr>
<tr><td>BR25 (Denmark)</td><td>Mandatary regulation with embodied carbon limits</td><td rowspan="3">• EPD (published by approved EPD program operators)
• National generic datasets when EPDs are not available</td></tr>
<tr><td>Climate Declaration (Sweden)</td><td>Mandatary regulation. Currently, embodied carbon value to be reported.</td></tr>
<tr><td>Low-Carbon Building Regulation, Finland</td><td>Mandatary regulation, with a maximum carbon footprint limit</td></tr>
<tr><td>RICS WLCA (UK)</td><td>Proposed regulation</td><td>• EPDs
• ICE database (UK geographical scope)
• Other recognised databases</td></tr>
<tr><td>Voluntary benchmarks like LETI, RIBA 2030, CLF, etc.</td><td></td><td>• EPDs are prioritised
• ICE database
• EC3 (primarily North America geographical scope)
• National and other recognised databases</td></tr>
</table>

INDIA-SPECIFIC CARBON INTENSITIES OR GWP OF BUILDING MATERIALS

Availability of India-specific GWP values of building materials is the most crucial data that is required regardless of the decisions on scope, building typologies and normalisation area. This is the most critical gap for embodied carbon calculations in India as there is no officially accepted database of GWP values in India. Table 5 shows the sources of material GWP values used in a few recent Indian studies.

Table 5: Material GWP sources used in Indian embodied carbon studies

Study name	Material GWP sources
GCCA India. (2025). Comparative Evaluation of Embodied Carbon of High-rise and Low-rise buildings in India[18]	• **Primary source:** IFC. (2017). Materials India Construction Materials Database of Embodied Energy and Global Warming Potential • **Other sources:** o PPC, PSC and GGBS: EPDs o Reinforcement steel: Annual reports of major steel manufacturers o Formwork: The Institution of Structural Engineers (IStructE), U.K.
CII-IGBC. (2025). Embodied Carbon Emissions Baseline Estimation for Buildings in India[19]	Not mentioned
Analysis carried out by RMI and Lodha Group for their residential buildings (2025)[20]	• **Primary sources:** o IFC. (2017). Materials India Construction Materials Database of Embodied Energy and Global Warming Potential o SimaPro (available with the paid software) • **Other sources:** IFC. (2017). Materials India Construction Materials Database of Embodied Energy and Global Warming Potential o Concrete: Calculated o Stone: The Inventory of Carbon and Energy (ICE) Database
Jain, M., & Rawal, R. (2022). Emissions from a net-zero building in India: life cycle assessment[21]	GWP for each material was calculated using at least five valid emission factors for that material. Validity was assigned using a consistency check.
GKSPL. (2024). Whole-life carbon analysis of residential buildings in India: Three case studies from Bengaluru[22]	• Cement, Glass: EPDs of the brand used or another similar Indian brand • Concrete, Reinforcement steel and Walling blocks: Calculated • Other materials: IFC database (2017), and international EPD where applicable.

GWP DISCLOSURES IN INDIAN BUILDING MATERIAL INDUSTRY

The EPD availability of Indian building materials is currently driven either by European or other international trade requirements or if a material is being explicitly sold as allow-carbon material. As of writing this document, there are around 250 EPDs for Indian building materials and products, with either global or Indian geographical scope on the International EPD system. Most of these are for cement, ready-mix concrete, glass, metal products including reinforcement steel, plasterboards and other boards, fenestration hardware, pipes and architectural solar films. A few EPDs are also available for paints, insulation, elevators, furniture, paver blocks and cooling elements.

Table 6 indicates availability of EPDs and national datasets for key building materials in India.

Table 6: Availability of EPDs and national datasets for key building materials in India.

Material	**Availability of GWP value**
Cement	Some Indian EPDs are available. Industry average GWP can be calculated and endorsed for OPC, PPC, PSC and other cement blends.
Reinforcement steel and other construction steel	Some Indian EPDs are available. Industry / sector average GWP can be calculated. It may be more complex than for cement as scrap percentages vary and presence of secondary and tertiary manufacturers. However, with the green steel taxonomy, better documentation is expected.
Concrete	Ideally, this must be calculated based on the concrete grade, mix ratios. Sector / regional / national average GWP required for supplementary cementitious materials (SCMs) and aggregates used in concrete.
Walling blocks	2 EPDs of Indian brick manufacturers available. Requires significant work to understand GWP of specific products as it is a highly fragmented (several types of walling blocks) and highly unorganised, while being very important for Indian building sector. Sector EPDs or LCAs are required.
Glass	Indian EPDs are available. Industry average GWP can be calculated and endorsed
Aluminium	No Indian EPDs available. Required for products like window frames, panels, framing etc which are widely used.
uPVC frames	No Indian EPDs available. Required as uPVC frames are widely used.
Flooring tiles	One EPD for Indian vitrified tile available. Sector average EPD may be feasible too as the Indian vitrified and ceramic tile industry is mainly located in Morbi, Gujarat. LCA / EPDs need to be developed for other flooring products
Timber	Average factors for timber used in India need to be developed, especially those used for door/window frames, door shutters and flooring.

There are a few issues in the availability and use of GWP of building materials:

- Several materials used in Indian buildings, most notably walling blocks, are locally produced by MSMEs. GWP of such materials is not available and they will also vary widely with location and manufacturing process.
- GWP of some key materials like aluminium is not easily available, and where available it may not be for the finished product being used in the building. For e.g. aluminium is used as door/window frames, façade panels, frame for partitions and false ceiling etc.
- Even when GWP numbers are available, they may not be categorised as per the LCA modules and may only be the manufacturing (A3) emissions. For e.g. the CCTS notification in India provides the carbon emissions of cement and steel plants, but they are likely the manufacturing (A3) emissions of the plant and do not include raw material (A1) and transportation-to-plant (A2) emissions.

REQUIREMENTS OF A NATIONAL DATABASE OF MATERIAL GWP

A national database of carbon intensities or GWP of building materials and products, for use in embodied carbon reporting and future benchmark compliance, should have material GWP with the following characteristics:

- **Follow EN 15804 + A2: 2019 reporting structure**

This is the most widely used material LCA reporting structure. Here, the material broken down by the life-cycle stages or LCA modules (i.e., A1-A3 product stage, A4 transport etc.) and the GWP is also reported for each LCA module in kgCO_2e per functional unit. Under this reporting structure, GWP-fossil, GWP-LULUCF and GWP-biogenic are reported separately.

- **Report GWP according to the life-cycle stages**

This will enable correct allocation of GWP based on the scope of the building embodied carbon methodology followed.

Most EPDs published since 2022 follow the above reporting structure and hence can be included in the database. National and sub-national data for key materials must also be reported in the same structure.

For the national datasets, it is recommended that the manufacturing process of materials, with inputs (raw materials and fuel) and outputs, is documented. EPDs are not uniformly detailed in showing the manufacturing process and can have a blind spot in that aspect.

EMBODIED CARBON REPORTING FRAMEWORK FOR DISCLOSURE AND FUTURE COMPLIANCE

The NITI Aayog report proposes that certain building categories disclose their embodied carbon data, which would help arrive at benchmarks for future compliance. The objective of such a framework, initially, is to promote transparency, build a national embodied carbon database, and strengthen market readiness. It would operationalise the LCA methodology and material GWP provisions outlined in the previous chapters and ensure that reported results are consistent and comparable.

Table 7: Suggested embodied carbon reporting framework

PROJECT INFORMATION	Project name and location
	Built-up area
	Building typology (Residential, office, institutional, commercial etc.)
	Structural system (Monolithic concrete, RCC frame + masonry, load bearing etc.)
	Height (with podiums, stilt floor etc. mentioned separately)
	Basement, if any
SYSTEM BOUNDARY CONFIRMATION	Life cycle modules included. As mentioned earlier, this could initially be A1-A3 stages
MATERIAL INFORMATION	Material category (Concrete, steel, masonry, plaster, doors and windows, flooring, cladding etc.)
	Building component where material is used (Substructure, Envelope, Interiors etc.)
	Quantity and unit
	Emission factor and functional unit
	Emission factor source
EMBODIED CARBON CALCULATION	Conversion factor from material quantity unit to material emission factor functional unit
	Calculation of emissions for each material category
EMBODIED CARBON SUMMARY	Total embodied carbon ($kgCO_2e$)
	Carbon intensity ($kgCO_2e/m^2$)
	GWP contribution by material category and building component
	Material use intensity of key materials (concrete in m^3/m^2, steel in kg/m^2 etc.)
ASSUMPTIONS AND LIMITATION	Any assumptions, exclusions etc. considered

SOURCES OF BUILDING MATERIAL QUANTITIES

During the initial disclosure phase, material quantities shall be derived from design-stage documentation, preferably the Bill of Quantities (BoQ). A BoQ is a structured document that provides a detailed, itemized list of materials, parts, and labor required for a building, and it is prepared primarily to enable consistent pricing comparison and contractual administration. While they are not the final as-built quantities, BoQs are the most practical primary source of material quantities as they are systematically prepared and itemised and provide traceable documentation. A BoQ generally also includes material wastage factors.

Where BOQ items aggregate multiple materials (e.g., concrete, masonry including blocks and mortar etc.), the framework will need to prescribe standard assumptions for disaggregation or allow reporting in aggregated. Table 8 gives examples of how the GWP of some key items from BoQs were calculated for this study.

In the absence of BoQ, detailed quantity take-offs from architectural and structural drawings and BIM derived quantities can be used.

Table 8: Examples of GWP calculation of key BoQ items in this study

BoQ item	Quantity unit in BoQ	GWP calculation
Concrete (all grades)	m^3	Kg CO_2e/m^3 This must ideally be calculated based on the specific mix ratio being used for the different concrete grades. The mix ratio gives quantities of cement, SCMs, and aggregates (all in kg) used to prepare 1 m^3 of said grade of concrete. EPDs of some Indian RMC is available.
Reinforcement steel and other construction steel	Kg or MT	Kg CO_2e/kg or t CO_2e / t
Masonry (includes type and thickness of brick / block and specification of mortar)	m^3 (for external walls) or m^2 (for internal walls)	Kg CO_2e/m^3 Quantities of bricks / blocks (in m^3), cement (in kg) and fine aggregate (in kg) use estimated for 1 m3 of masonry. GWP calculated by adding the GWP of bricks / blocks, cement and fine aggregate used in 1 m^3 masonry.
Flooring (specifies type of flooring with required mortar)	m^2	Kg CO_2e/m^2 Quantities of floor tiles (in m^2), cement (in kg) and aggregate (in kg) use estimated for 1 m^2 of flooring. GWP calculated by adding the GWP of tiles, cement and aggregate used in 1 m^2 flooring.
Factory fabricated glazed windows (specifies window type, frame and glass type). These are usually aluminium or uPVC framed	m^2	Quantities of frame (in kg) and glass (in m^2) are separately calculated. Emissions from all glazed windows is then calculated by adding the emissions from the frame material and glass used in the building.
Site-fabricated windows	Glass (m^2) Frame, if timber (cu.ft. or kg)	BoQ usually has separate items for frame material (for e.g. timber in cubic feet or kg) and glass in m^2. Emissions from these windows can be calculated by adding the emissions from the frame material and glass.

ESTABLISHING BASELINES AND BENCHMARKS

BUILDING TYPOLOGIES AND SUB-CATEGORIES

Residential, office and educational buildings are the building categories for which separate values are defined in most existing embodied carbon benchmarks. The residential benchmark is usually for multi-family residential buildings or in some cases further differentiated between detached / semi-detached / row housing and group housing (e.g. the French RE2020 regulation and the Danish BR25 regulation). In addition, some baseline and benchmark studies have values for other building typologies like retail, public assembly, warehouse, healthcare, hotels, sports, cultural, industrial production and transport.

As building embodied carbon data is scarce in India, the priority must be in conducting embodied carbon calculations, encouraging embodied carbon reporting and building a database for embodied carbon for several building typologies and sub-categories. This will help develop the baseline for these building categories and help understand the impact of different building features, materials and other conditions on its embodied carbon.

The first level of categorisation is building typology, for e.g. residential, office, healthcare, warehouse etc. One may refer to the categories in the Energy Conservation and Sustainable Building Codes (ECSBC). Each building typology must be further categorised into sub-categories. This report recommends the following sub-categories

- Seismic zone (Zone II to Zone VI)
- Building height
- Construction technology
- Parking type

DEVELOPING THE REPOSITORY FOR BASELINING AND BENCHMARKING

There are a few key challenges in building the repository of samples for baselining.

- Collecting Bill of Quantities (BoQs) takes significant time. Data collection for a single project for this study has taken anything between 1 month to 10 months. This included:
  - Getting approval from the developer,
  - Explaining the data requirements to the concerned teams, which includes the sustainability team, projects team, procurement team, design team, as well as the contractor.
  - Ensuring BoQ data quality and processing for use in embodied carbon calculations

- In the absence of a national database or permissible databases, finding valid material GWP was an uncertain and time-consuming exercise.

RECOMMENDATIONS: A multi-pronged approach needs to be taken to build the repository of samples for baselining. Three key initial actions have been detailed in the previous chapters, viz,

- Endorsement of standard building LCA methodology for embodied carbon calculation in India
- Publication of permissible India-specific carbon intensities or GWP of building materials
- Developing embodied carbon reporting framework and mandating embodied carbon disclosure

In addition to the above, two other actions are crucial.

- Capacity building of building teams and other stakeholders to generate consistent, usable embodied-carbon data. This is discussed in detail in a later chapter.
- Commission independent studies for embodied carbon calculations, following the endorsed methodology, where required. These studies could be in two forms:
    - Embodied carbon calculated based on BoQs from sample buildings, as done in this study. This is feasible for buildings of certain types and size where BoQs are prepared.
    - Embodied carbon calculated on the basis of typical design and using material take-off quantities from drawings or BIM models, while considering different material and structural system options for the same design. Such an exercise can help estimate embodied carbon variations within the same typical design and finding the option with the best design and material use efficiency. This type of study is especially important for simple and smaller buildings where BoQs may not be prepared, for e.g. individual affordable homes.

4.3 Enabling on-ground embodied carbon reduction through regional roadmaps

The act of measuring and reporting embodied carbon alone does not reduce emissions, but having a baseline, and benchmarks subsequently, enable policy, market, and technological responses that can progressively decouple growth in the buildings sector from emissions intensity. The implications of embodied carbon benchmarks broadly drive on-ground action in the following ways.

- Compliance instruments for buildings to reduce embodied carbon through design and material choices
- Building material procurement policies
- Material transition strategy
- Circular construction policies prioritised where needed.

These four points can form the key points for regional or city-level roadmaps for embodied carbon reduction. These points are also not sequential but form a feedback loop where compliance instruments increase demand for better material data and more procurement; improved data enables more effective benchmarks; and successful embodied carbon reduction lowers the baseline over time.

EMBODIED CARBON BENCHMARKS AS COMPLIANCE INSTRUMENTS

A direct objective of developing embodied carbon baselines and benchmarks is to not just have them as reference values but as compliance instruments, either through regulation or market mechanisms. In the Indian context, compliance is unlikely to emerge immediately as a regulation. Instead, it is more likely to be introduced through conditional requirements, some of which already exist. For e.g.

- Climate finance taxonomy for buildings
- Eligibility criteria for green finance instruments like green bonds
- Evaluation points in voluntary green rating systems
- Criteria for carbon markets
- Condition for municipal incentives or approvals

A roadmap should contain embodied carbon benchmarks that represent the locally prevalent building typologies, construction technologies, materials and material GWP.

BUILDING MATERIAL PROCUREMENT POLICIES

Procurement policies are a practical means to reduce embodied carbon through market-driven intervention. Procurement policies mandating or prioritising low-carbon materials can create demand for these materials, enable economies of scale, and encourage manufacturers to invest in cleaner technologies and to provide verified Environmental Product Declarations (EPDs).

A procurement policy / guideline is a key pillar of a regional roadmap that can align local building and infrastructure development plans with national decarbonisation goals. These can be adapted by public and private building material procurement teams. Some components forming a regional procurement policy are:

- Identify and require use of materials to adhere to different building codes and standards. For e.g. a procurement policy can require the use of low U-value walling and roof assembles or insulation on walls and roof to comply with ECSBC requirements.
- Identify high-impact embodied carbon materials and set low-carbon specifications: Typically, these materials are concrete, cement, steel, masonry, aluminium, glass and tiles. Low GWP specifications must be provided for these. For e.g.
  - Performance-based concrete specifications using higher percentage of SCMs
  - Cement replacement with fly ash, slag, or calcined clay
  - Recycled or scrap steel with high content
  - AAC, fly ash bricks, hollow bricks etc. instead of fired clay bricks, depending on local availability
- Require and promote the use of verified EPDs for material selection
- Drive supplier engagement and market development by:
  - Identifying and mapping suppliers capable of providing low-carbon materials.
  - Provide guidance or training to suppliers on emissions reporting and cleaner manufacturing processes
  - Offering preferential procurement, recognition, or incentives to suppliers who provide verified low-carbon products.
  - Developing and including regional catalogues of preferred low-carbon materials
- Provide template procurement contracts with clauses for low-carbon material specifications and supplier responsibility for verified data

SUPPLY-SIDE MATERIAL TRANSITION STRATEGY

On the supply side, policy push for R&D, industry transition and financing is required for:

- Material innovations such as low-clinker cements, alternative binders, green steel, low carbon walling blocks etc.
- Process improvements, energy efficiency, and fuel switching
- Greater utilisation of industrial by-products and circular material flows
- Standards and labels to prove low-carbon product to enable easy identification and procurement
- Support to the material industry to conduct material LCAs and produce EPDs, especially those from MSMEs

Within a regional roadmap, the focus should be on materials used and manufactured locally. For e.g. a material transition strategy for south and west India can focus on:

- Process and scrap percentage improvements in secondary steel manufacturing units
- Innovations to lower emissions from solid concrete blocks which are widely used.
- Process improvements, fuel switching and kiln design of fired clay products like bricks, tiles etc.
- Potential transition of existing manufacturing units for fired bricks to low-embodied carbon versions like hollow clay blocks
- Improve production and availability of compressed stabilised earth blocks (CSEBs) which are well-accepted in South India
- Improve usability and availability of other low-carbon walling bricks incubated and manufactured in the region like agri-based blocks in South India

CIRCULAR CONSTRUCTION POLICIES PRIORITISED WHERE NEEDED

India's development plan will entail construction activity that will far surpass the generation of construction and demolition (C&D) waste, and development of building materials from other waste streams. However, that does not imply that circular construction principles are neglected.

Circular construction policies are most effective and must form a core pillar of an embodied carbon reduction roadmap in regions undergoing intensive redevelopment, where demolition and reconstruction cycles generate both material demand and material supply, for e.g. the Mumbai Metropolitan Region. In contrast, regions dominated by greenfield expansion will derive greater near-term benefit from material efficiency and low-carbon production strategies rather than reuse-driven circularity.

4.3 Awareness and capacity building

Addressing embodied carbon will require sector-wide awareness and targeted capacity building across the building value chain. Every stakeholder must understand the basics of embodied carbon, their influence on embodied carbon outcomes, the decisions under their control, any reporting and compliance requirements relevant to them and the practical levers for reduction.

Stakeholders have been categorised into three primary groups to identify the type of knowledge, capacity building, and training:

- **Regulators and enablers:** This group sets the rules, creates mandates and shape incentives. It includes national and state governments, urban local bodies (ULBs), standards-setting agencies, financial institutions and investors, multilateral lenders etc.
- **Asset creators, owners and technical service providers**: This group commissions, designs, builds the building as well as reports. This includes developers, building owners, public sector building and development agencies, as well as their technical service providers.
- **Material manufacturers and suppliers:** This group manufactures and supplies building materials and products

Table 9, Table 10 and Table 11 propose the awareness building and training focus for each group, with a greater emphasis on the second group.

Table 9: Proposed capacity building focus for regulators and enablers

Stakeholder	Awareness building	Targeted training
Regulators and enablers	• Understanding of whole-life carbon • Role of embodied carbon in national climate targets • International best practices for disclosure, benchmarking, low-carbon procurement etc. • Financial and policy levers to incentivize carbon reduction	• Carbon accounting and reporting frameworks • Integrating embodied carbon into building codes and procurement rules • ESG-linked lending and carbon-linked KPIs

Table 10: Proposed capacity building focus for asset creators, owners and technical service providers

<table>
<tr><th>Stakeholder</th><th>Awareness building</th><th>Targeted training</th></tr>
<tr><td>Developers and Owners</td><td rowspan="2">• Basic understanding of whole-life carbon
• Portfolio-level carbon exposure
• Compliance requirements
• Reputational and regulatory risk
• Link to national climate commitments</td><td></td></tr>
<tr><td>Sustainability teams</td><td>• Whole-life carbon concepts and terminology
• Major material carbon drivers
• Reading and evaluating EPDs and other material GWP sources
• Basic carbon intensity metrics ($kgCO_2e/m^2$)
• Embodied carbon calculation and reporting
• Handling data gaps and uncertainty</td></tr>
<tr><td>Architects</td><td>• Basic understanding of whole-life carbon
• Impact of design and material choice
• Trade-offs between aesthetics, cost, and carbon
• Basic lifecycle stages (A1–A5 focus)
• Material GWP from EPDs and other sources</td><td>• Concept-stage carbon estimation
• Material substitution strategies
• Design for material efficiency
• Design for adaptability and reuse</td></tr>
<tr><td>Structural engineers</td><td>• Basic understanding of whole-life carbon
• Carbon implications of concrete grades, reinforcement ratios, and steel sourcing
• Basic lifecycle stages (A1–A5 focus)
• Material GWP from EPDs and other sources</td><td>• Optimization of structural design
• Quantity-based carbon calculations
• Low-carbon concrete and recycled steel applications</td></tr>
<tr><td>Quantity surveyors and cost consultants</td><td>• Basic understanding of whole-life carbon
• Carbon hotspots in BoQs
• Relationship between cost and carbon intensity</td><td>• BoQs structured to allow material quantity extraction for carbon reporting</td></tr>
<tr><td>Procurement team</td><td>• Basic understanding of whole-life carbon
• Carbon hotspots
• Material GWP from EPDs and other sources</td><td>• Reading and evaluating EPDs and other emission factor sources</td></tr>
</table>

	• Relevant material labels • Low-carbon material alternatives	• Mandating and evaluating supplier carbon disclosure / EPD submissions • Evaluating carbon alongside cost and other metrics
Contractors and construction management teams		• Record as-built quantities • Document substitutions, material sources, logistics, waste, on-site energy use • Construction waste reduction and management practices
Skilled construction workforce		• Using and installing low carbon materials

Table 11: Proposed capacity building focus for material manufacturers and suppliers

Stakeholder	Awareness building	Targeted training
Material manufacturers and suppliers	• Understanding of whole-life carbon • Understanding the market shift toward low-carbon materials • Competitiveness through carbon disclosures and EPDs • Regulatory and financial requirements and potential incentives	• LCA and carbon assessment • Process decarbonization strategies • Preparing verified EPDs and reporting carbon performance

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Annexure I

Material carbon emission factors considered

Material	Description	Functional Unit (FU)	$kgCO_2$/FU	Source
Concrete (with 25-50 % GGBS range)	M7.5	m^3	109.14- 161.04	Calculated- Plant Data, Mix Certificates from the Developers
	M10	m^3	128.28- 175.39	
	M15	m^3	185.49- 244.89	
	M20	m^3	229.60- 281.88	
	M25	m^3	191.22- 410.94	
	M30	m^3	206.19- 290.76	
	M30SCC	m^3	268.33- 358.19	
	M35	m^3	217.49- 306.41	
	M40	m^3	229.46- 327.11	
	M40SCC	m^3	236.53- 400.01	
	M45	m^3	194.41- 257.60	
	M45F	m^3	268.97- 290.97	
	M50	m^3	289.88	
	M50SCC	m^3	317.05	
	M60	m^3	252.96- 408.22	
	M60SCC	m^3	328.19- 408.79	
	Mix 1:3:6	m^3	135.04- 176.69	
Concrete (without GGBS)	M10	m^3	188.48- 226.57	
	M15	m^3	333.81	
	M20	m^3	424.88	
	M25	m^3	341.05	
	M30	m^3	374.68	
	M35	m^3	394.36	
Concrete (with 25-30 % Fly Ash)	M10	m^3	177.70	
	M15	m^3	242.21- 260.05	
	M20	m^3	299.64	
	M25	m^3	401.58- 437.61	
	M30	m^3	274.16- 311.94	
	M35	m^3	305.44	
	M40	m^3	324.30- 363.32	
	M45	m^3	257.60	
	M50	m^3	411.79	
	M60	m^3	408.22	
	M70	m^3	472.85	
Cement	OPC	kg	0.996	Ultratech EPD India[23]
Cement	PPC	kg	0.731	Ambuja EPD India[24]
M sand		kg	0.0071	Calculated- Partial Plant Data
Aggregates		kg	0.0058	
Reinforcement Steel	75% Scrap	kg	1.96	Calculated -Expert Consultation
	40% Scrap	kg	2.81	
	20% Scrap	kg	3.25	
	10% Scrap	kg	3.48	

	0% Scrap	kg	3.72	
Reinforcement Steel	5-star steel	kg	1.6	Green Steel Taxonomy India 2024[25]
Structural Steel		kg	3.67	Jindal Steel EPD India[26]
Concrete Blocks		m^3	169.66	Calculated-plant data
Glass	6 mm Planilux	m^2	19.00	Saint Gobain EPD India[27]
	4mm Planilux	m^2	13.00	Saint Gobain EPD India[28]
	5mm Planilux	m^2	16.80	Saint Gobain EPD India[29]
	8mm Planilux	m^2	25.90	Saint Gobain EPD India[30]
Aluminum Profiles		kg	24.60	International EPD[31]
Wooden Flush Doors		m^2	18.30	International EPD[32]
Fire Rated Doors		m^2	110.00	International EPD[33]
UPVC Profiles		kg	3.35	Research and Calculations
Gyproc Plaster		kg	0.0563	Saint Gobain EPD India[34]
Mud Block		m^3	142.90	Calculated- Plant Data
Marble Tiles		m^2	8.06	International EPD[35]
Granite		m^2	5.640	One Click LCA
Vitrified/Ceramic Tiles		m^2	24.15	Comet Granito EPD India[36]
Wooden Flooring		m^2	21.50	IFC Database 2017[37]
Porotherm Bricks		m^3	56.40	Wienerberger India LCA Report [38]
AAC Blocks		m^3	196.10	International EPD[39]
Clay fired bricks		m^3	198.90	CATE 2023[40]
Hurdi blocks		m^3	137.30	CATE 2023[41]
Fly ash bricks		m^3	120.00	GKSPL[42]
Timber Frames		m^2	2.40	IFC 2017[43]
Cement tiles		m^2	25.5	IFC 2017[44]
Kota stone		m^2	3.00	IFC 2017[45]
Rubber tiles		m^2	16.10	International EPD[46]
PUF (30 mm)		m^2	30.6	One Click LCA
Galvanised Roofing Sheet		m^2	26.50	International EPD[47]

23 EPD-IES-0005019:001 (S-P-05019), EPD International, Cement Product (OPC, PPC, PSC)

24 EPD-IES-0022524:001, EPD International, PPC Ambuja Cement

25 Green Steel Taxonomy India (2024); Accessed from https://steel.gov.in/green-steel-taxonomy-india

26 EPD-IES-0009803:001 (S-P-09803), EPD International, Structural Steel

27 EPD-IES-0009213:002 (S-P-09213), EPD International, Planilux 6mm

28 EPD-IES-0022636:002, EPD International, Planilux 4mm

29 EPD-IES-0019899:002, EPD International, Planilux 5mm

30 EPD-IES-0005466:002, EPD International, Planilux 8mm

31 S-P-10616, EPD International, Extruded Aluminium Profiles

*32 EPD-IES-0011102:004 (S-P-11102), EPD International, FD-30 Flush Solid Core Timber Door 2040*926*44 mm*

33 EPD-IES-0016411:001, EPD International, MD 61 Class RC 1

34 EPD-IES-0015233:003, EPD International, Gyproc Elite 100

35 Polycor Marble EPD, Accessed from https://www.polycor.com/wp-content/uploads/2023/03/EPD_Marble-Floor-and-Pavers-1.pdf

36 SCS- EPD- 10237, Comet Granito Private Limited, https://granicer.in/assets/img/certi/SCS-EPD.pdf

37 India construction materials database of embodied energy and global warming potential methodology report: Accessed from https://edgebuildings.com/wp-content/uploads/2022/04/IFC-India-Construction-Materials Database-Methodology-Report.pdf

38 Wienerberger India LCA Report (2024), LEAD Consultancy, https://www.constructionweekonline.in/business/eco-friendly-construction-wienerberger-indias-smart-bricks-leads-in-carbon-reduction

39 S-P- 01259, EPD International, Autoclaved Aerated Concrete

40 Dr. Sameer Maithel, Innovative Burnt Clay Brick Construction Technology for Low-Carbon & Resource Efficient Housing in the Indo-Gangetic Plains.

41 ibid

42 GKSPL Study 2017, Roadmap for Promoting Resource Efficient Bricks in India: A 2032 strategy.

43 India Construction Material Database of Embodied Energy and Global Warming Potential Methodology Report, Accessed from https://edgebuildings.com/wp-content/uploads/2022/04/IFC-India-Construction-Materials-Database-Methodology-Report.pdf

44 ibid

45 ibid

46 EPD-IES-0010630:001 (S-P-10630), EPD International, Flexxer Resilient Rubber Flooring.

47 Tata Steel EPD Europe, Accessed from https://products.tatasteelnederland.com/sites/producttsn/files/Tata%20Steel%20EPD%20RoofDek%20D35%200.9mm%20steel%20052021.pdf

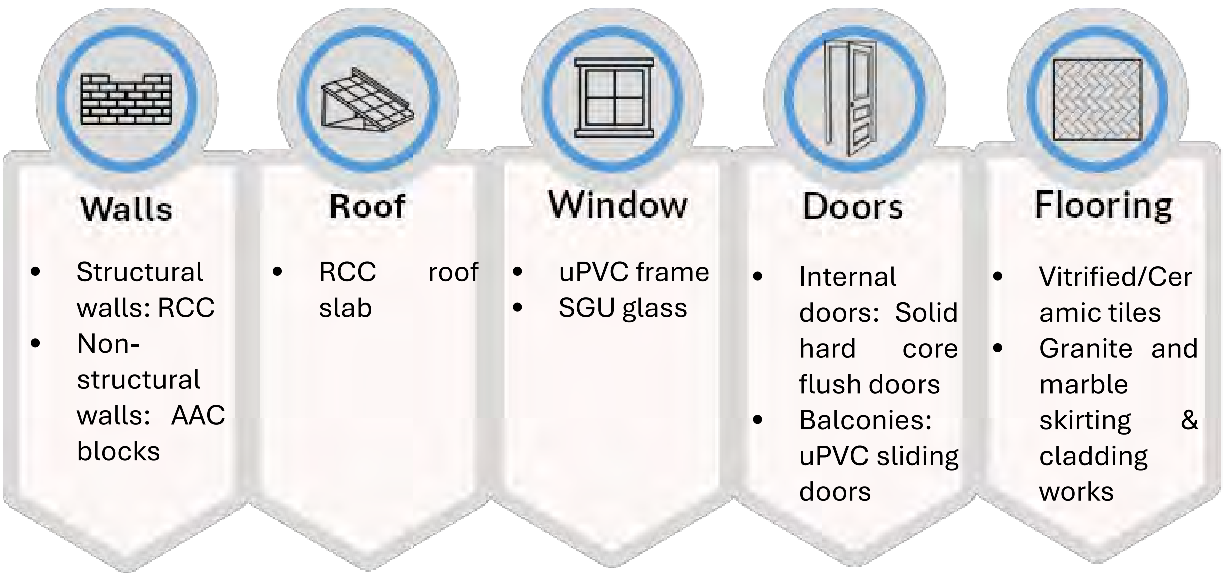
Annexure II

Product stage (A1 -A3) embodied carbon analysis of participating projects

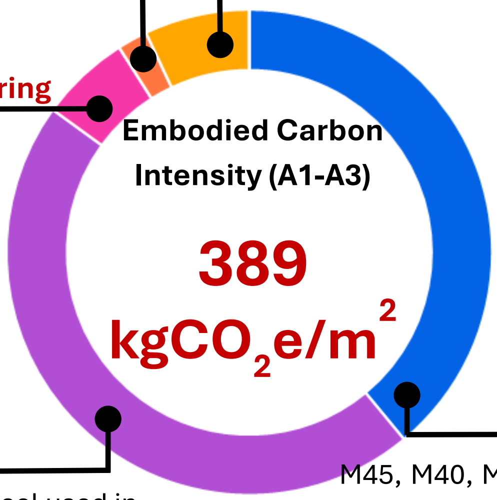
Building code: Z2-H-MC-B-1

High-rise residential project consists of four residential towers (26 storeys), a clubhouse, and a two-level basement underneath, and one stilt on ground.

Building location	Bengaluru
Seismic zone	Zone 2
Height	High-rise
Structural system	Monolithic concrete
Parking	Basement
Foundation type	Raft and isolated column footings
Number of basements	2
Number of floors above ground	Stilt+G+24
Built-up area (BUA) (m^2)	104962.45



PRODUCT WISE EMISSIONS SHARE



PPC has been used in plastering and other cement mortar works.

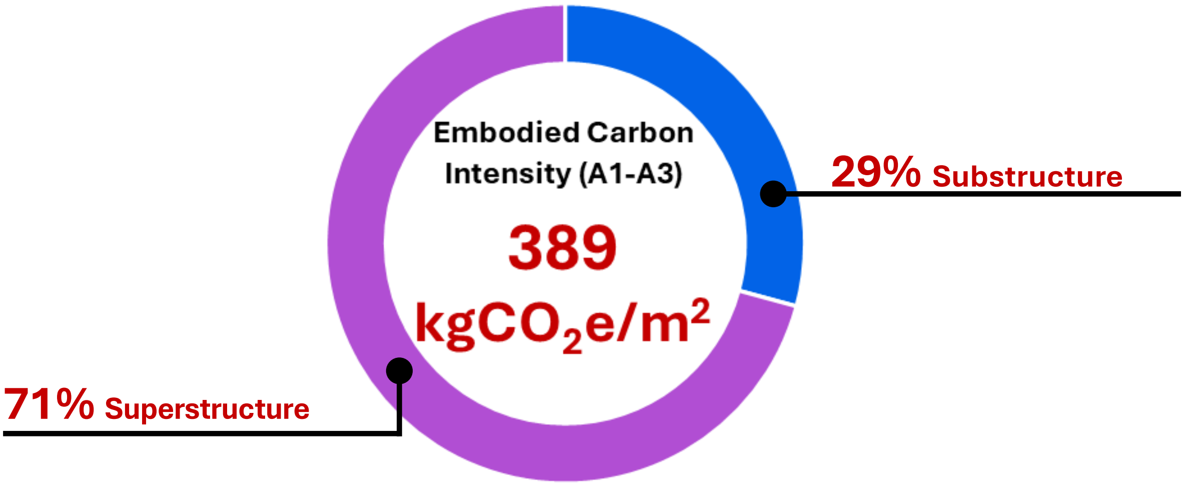
The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 63.83 kg/m^2 BUA

M45, M40, M35, M30, and M25 grades of concrete have been used. 30% cement of all concrete grades has been replaced with GGBS.

Concrete use intensity: 0.55 m^3/m^2 BUA

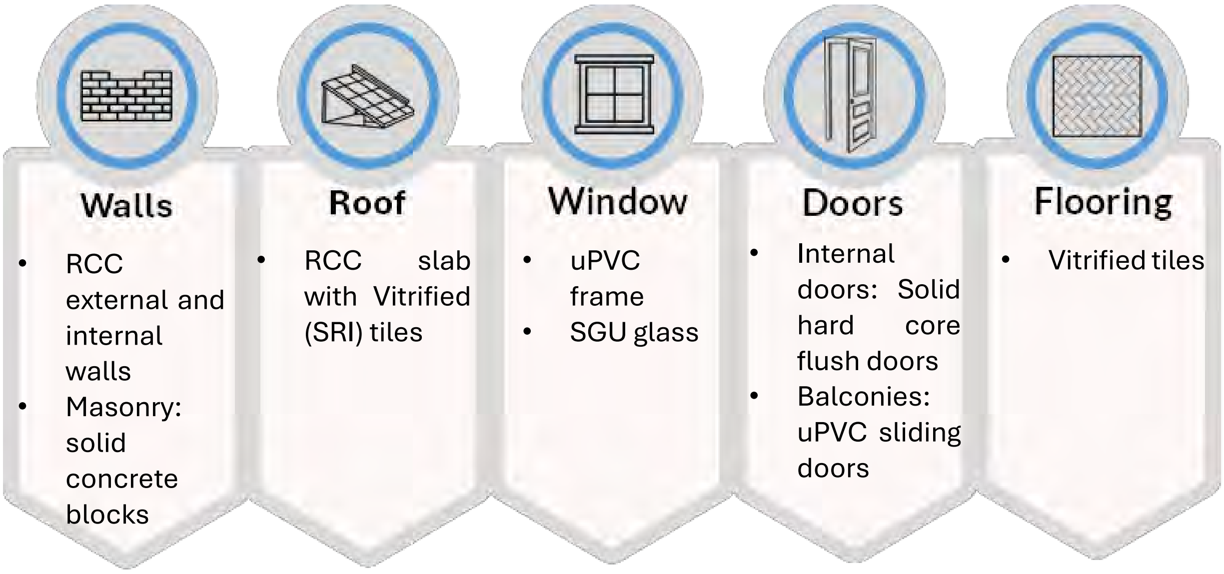
COMPONENT WISE EMISSIONS SHARE



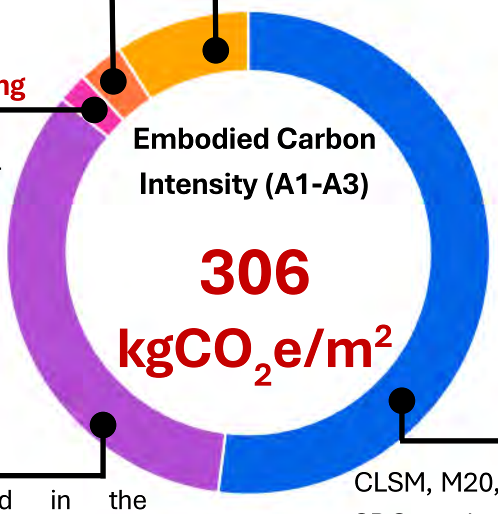
Building code: Z2-H-MC-B-2

High-rise residential project consists of two residential towers (31 storeys), a clubhouse, and a two-level basement underneath.

Building location	Bengaluru
Seismic zone	Zone 2
Height	High-rise
Structural system	Monolithic concrete
Parking	Basement
Foundation type	Raft and isolated column footings
Number of basements	2
Number of floors above ground	G+30
Built-up area (BUA) (m^2)	84352.13



PRODUCT WISE EMISSIONS SHARE



3% Windows & Doors

9% Flooring & Cladding

2% Masonry & Plastering

PPC has been used in plastering and other cement mortar works.

34% Steel

75% scrap steel used in the reinforcement steel.

Steel use intensity: 53.24 kg/m^2 BUA

52% Concrete

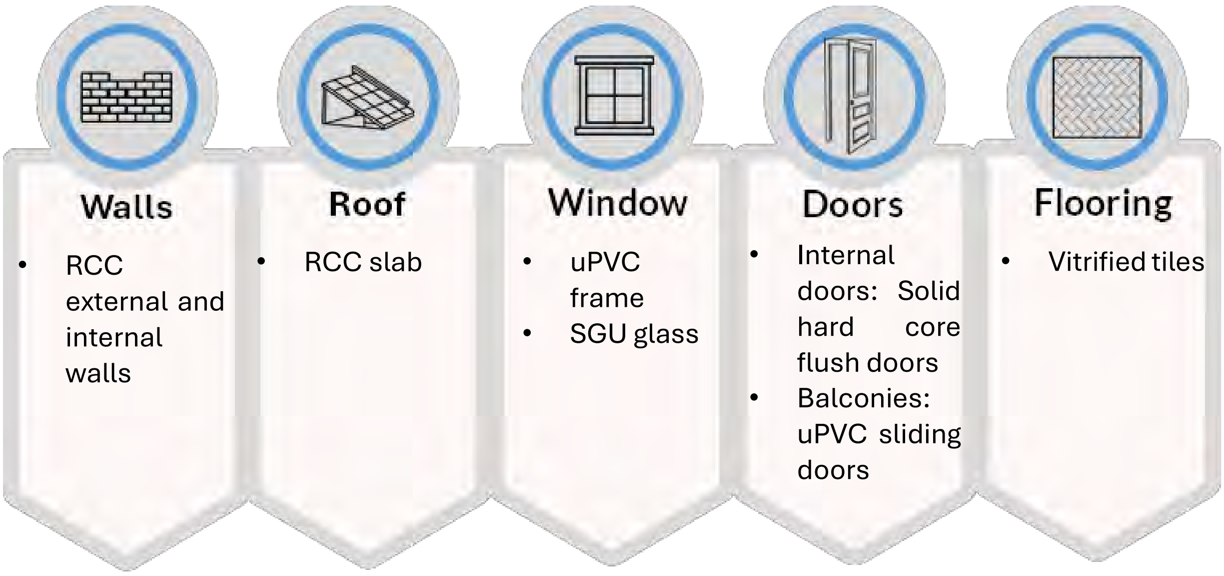
CLSM, M20, M30, M30 SDC, M40, and M40 SDC grades of concrete have been used. 25%-38% of the cement in different grades has been replaced with GGBS.

Concrete use intensity: 0.58 m^3/m^2 BUA

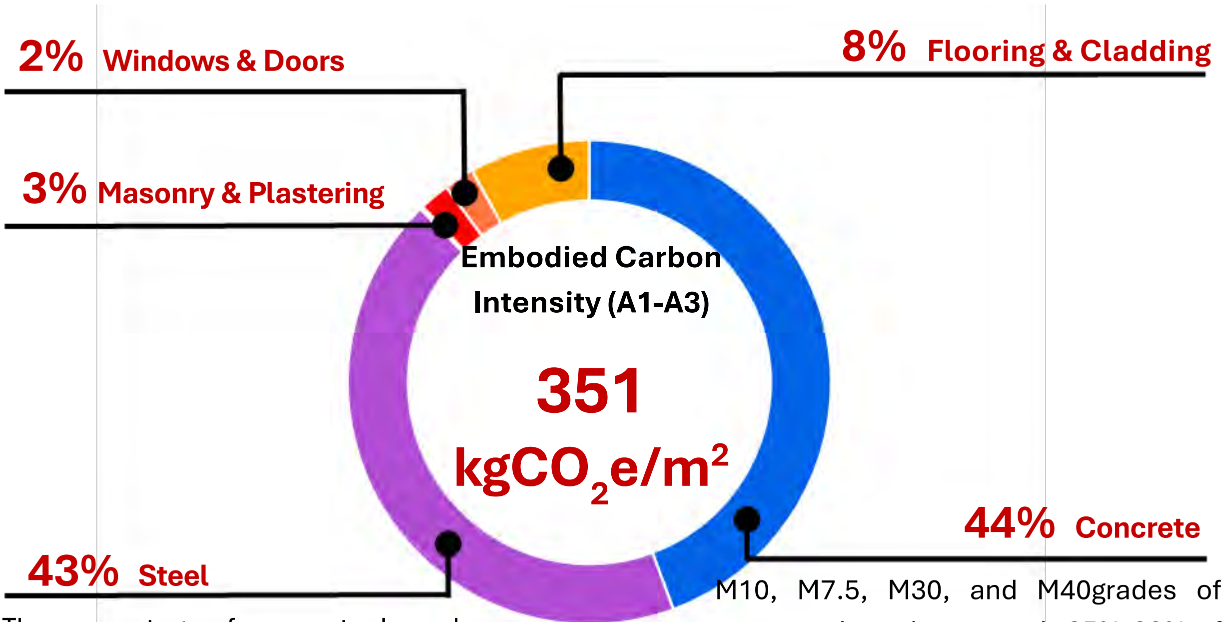
Building code: Z2-H-MC-B-3

High-rise residential project consists of fourteen residential towers (25 storeys), a club house, and a one-level basement underneath.

Building location	Bengaluru
Seismic zone	Zone 2
Height	High-rise
Structural system	Monolithic concrete
Parking	Basement
Foundation type	Raft Footings
Number of basements	1
Number of floors above ground	G+24
Built-up area (BUA) (m^2)	345990.32



PRODUCT WISE EMISSIONS SHARE



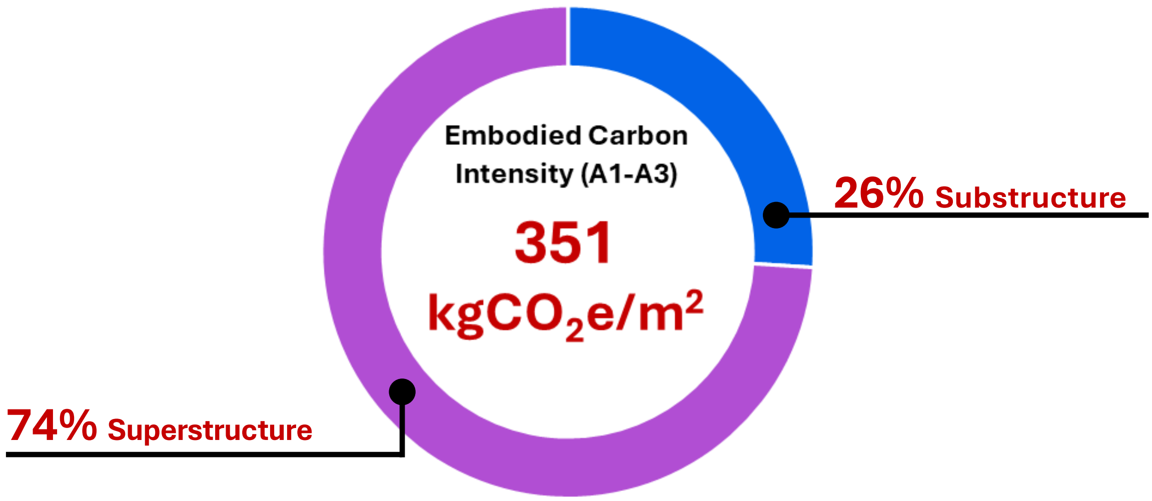
The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 54.07 kg/m^2 BUA

M10, M7.5, M30, and M40grades of concrete have been used. 25%-30% of the cement in different grades has been replaced with GGBS.

Concrete use intensity: 0.54 m^3/m^2 BUA

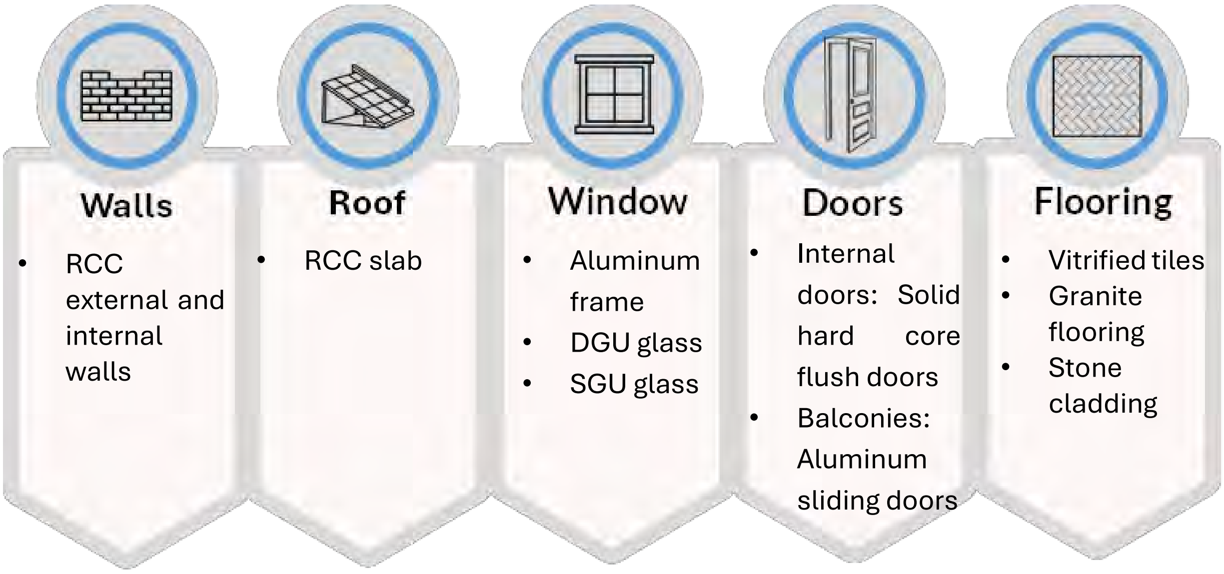
COMPONENT WISE EMISSIONS SHARE



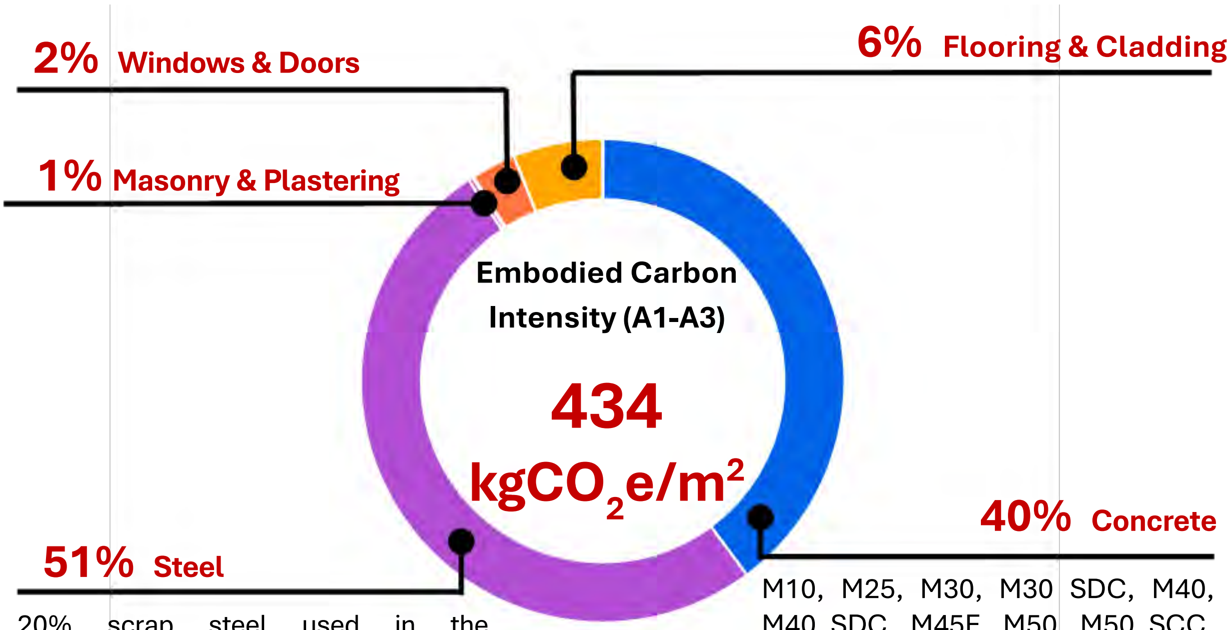
Building code: Z2-H-MC-B-5

High-rise residential project consists of eight residential towers (45 storeys), a clubhouse, and a four-level basement underneath.

Building location	Hyderabad
Seismic zone	Zone 2
Height	High-rise
Structural system	Monolithic concrete
Parking	Basement
Foundation type	Raft Footings
Number of basements	4
Number of floors above ground	G+44
Built-up area (BUA) (m^2)	755839.34



PRODUCT WISE EMISSIONS SHARE



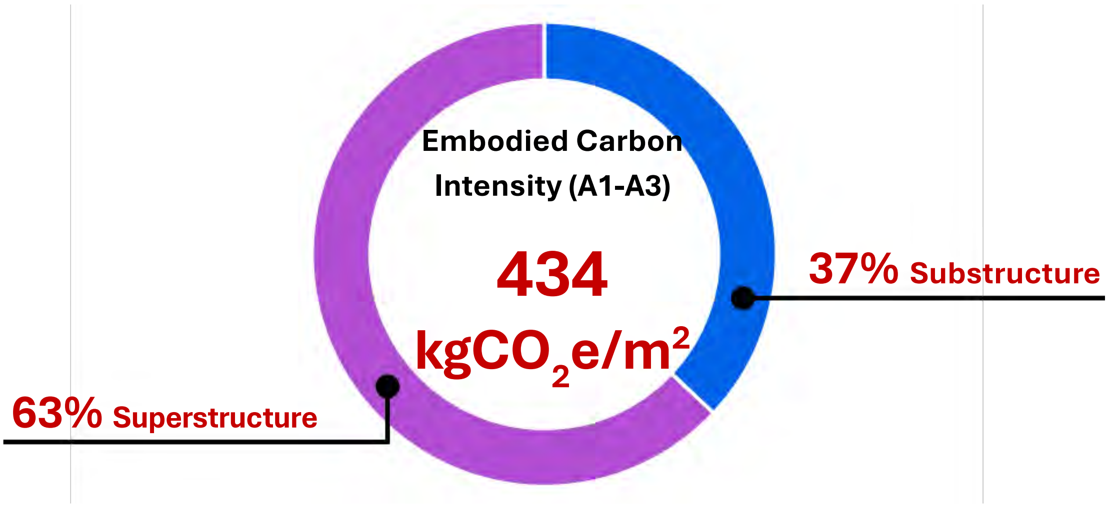
20% scrap steel used in the reinforcement steel.

Steel use intensity: 66.7 kg/m^2 BUA

M10, M25, M30, M30 SDC, M40, M40 SDC, M45F, M50, M50 SCC, M60, M60 SCC grades of concrete have been used. 30%-57% of the cement in all concrete grades has been replaced with GGBS.

Concrete use intensity: 0.67 m^3/m^2 BUA

COMPONENT WISE EMISSIONS SHARE



Building code: Z2-H-MC-B-6

High-rise residential project consists of thirteen residential towers (20 storeys), a clubhouse, and a two-level basement underneath.

Building location	Bengaluru
Seismic zone	Zone 2
Height	High-rise
Structural system	Monolithic concrete
Parking	Basement
Foundation type	Raft Footings
Number of basements	2
Number of floors above ground	G+19
Built-up area (BUA) (m^2)	168562.72

Walls

- RCC external and internal walls

Roof

- RCC slab

Window

- Aluminum frame
- uPVC frame
- SGU glass

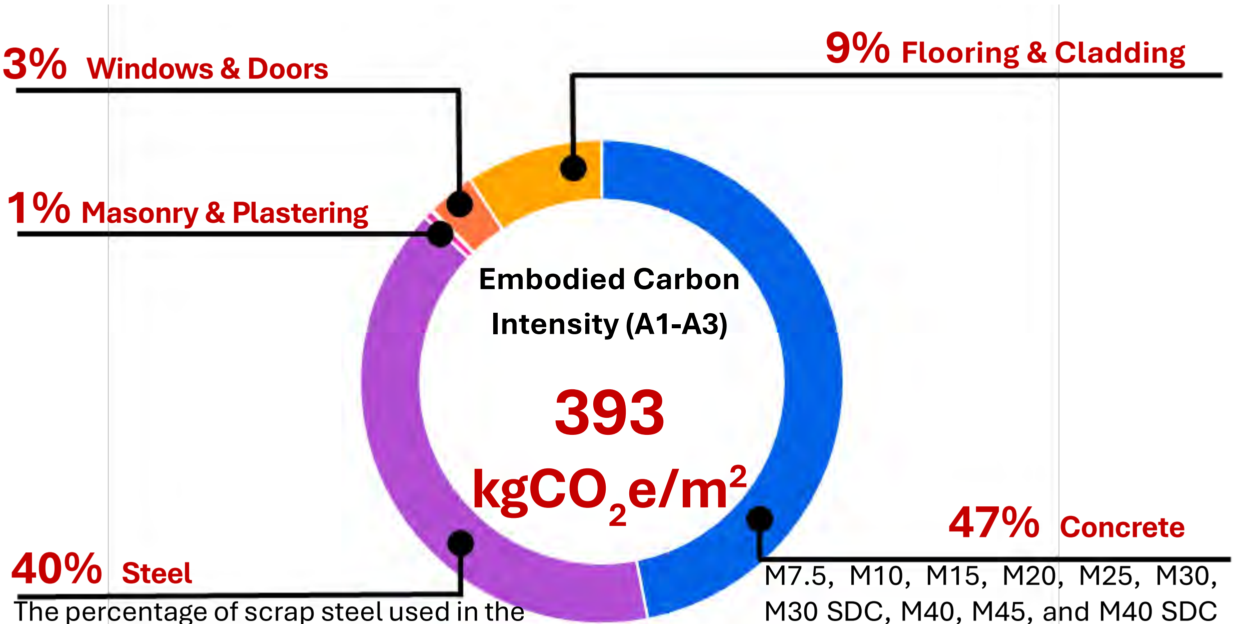
Doors

- Internal doors: Solid hard core flush doors
- Balconies: Aluminum/uPVC sliding

Flooring

- Vitrified tiles
- Ceramic tiles
- Granite flooring

PRODUCT WISE EMISSIONS SHARE



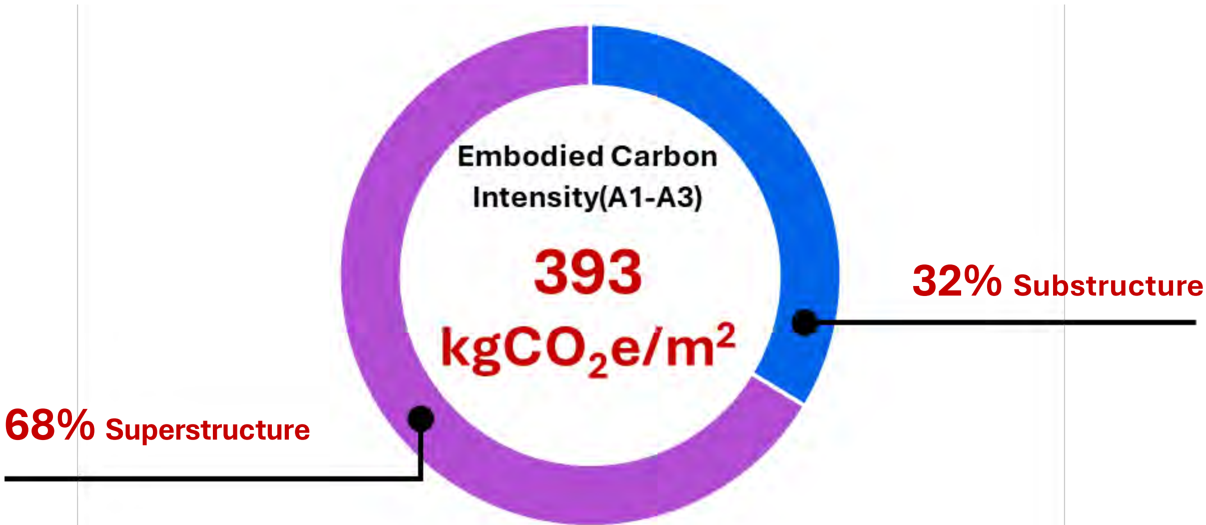
The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 56.47 kg/m^2 BUA

M7.5, M10, M15, M20, M25, M30, M30 SDC, M40, M45, and M40 SDC grades of concrete have been used. 30% of the cement in all concrete grades has been replaced with GGBS.

Concrete use intensity: 0.57 m^3/m^2 BUA

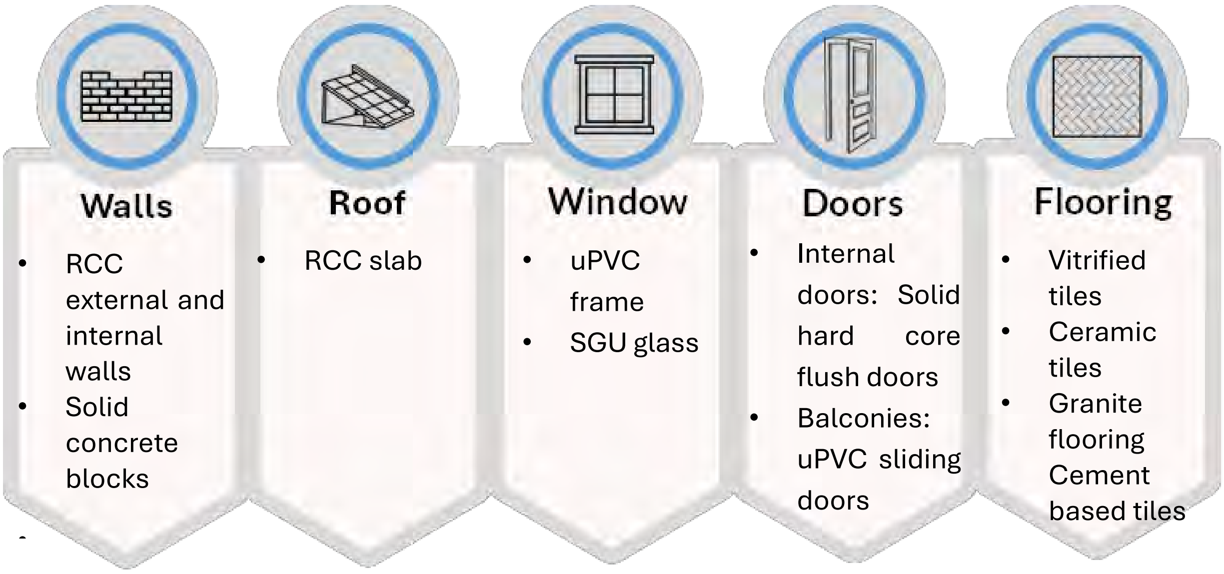
COMPONENT WISE EMISSIONS SHARE



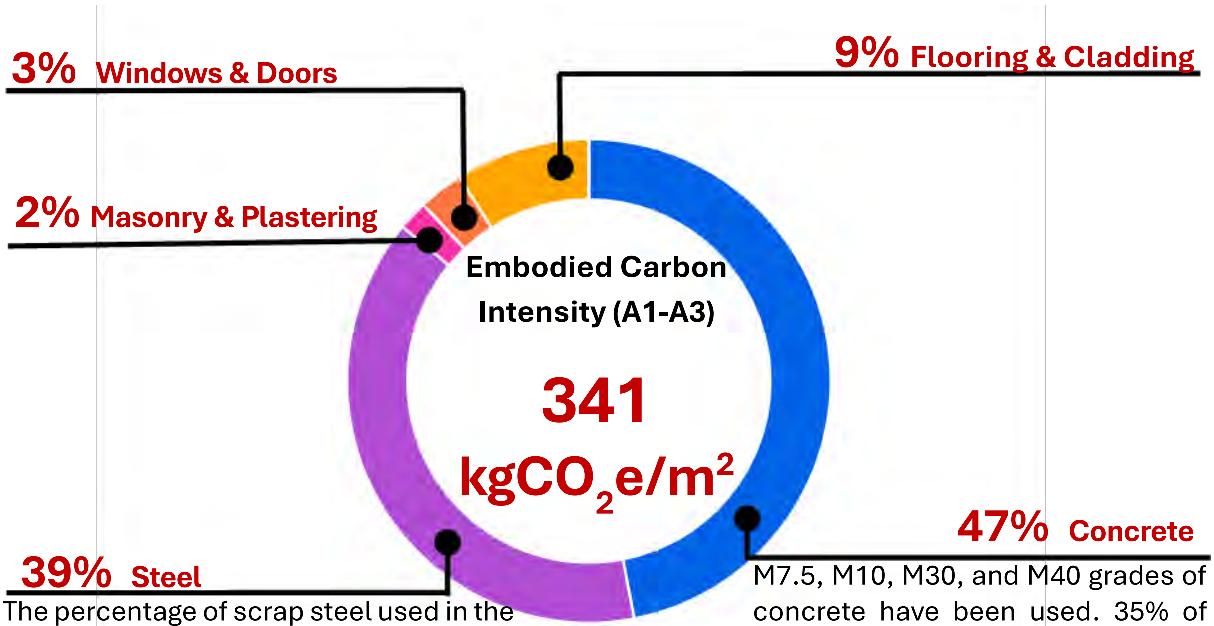
Building code: Z2-H-MC-B-7

High-rise residential project consists of four residential towers (29 storeys), a clubhouse, and a two-level basement underneath.

Building location	Bengaluru
Seismic zone	Zone 2
Height	High-rise
Structural system	Monolithic concrete
Parking	Basement
Foundation type	Isolated and combined footings
Number of basements	2
Number of floors above ground	Tower A,C: G+26 Tower B,D: G+28
Built-up area (BUA) (m^2)	93347.36



PRODUCT WISE EMISSIONS SHARE



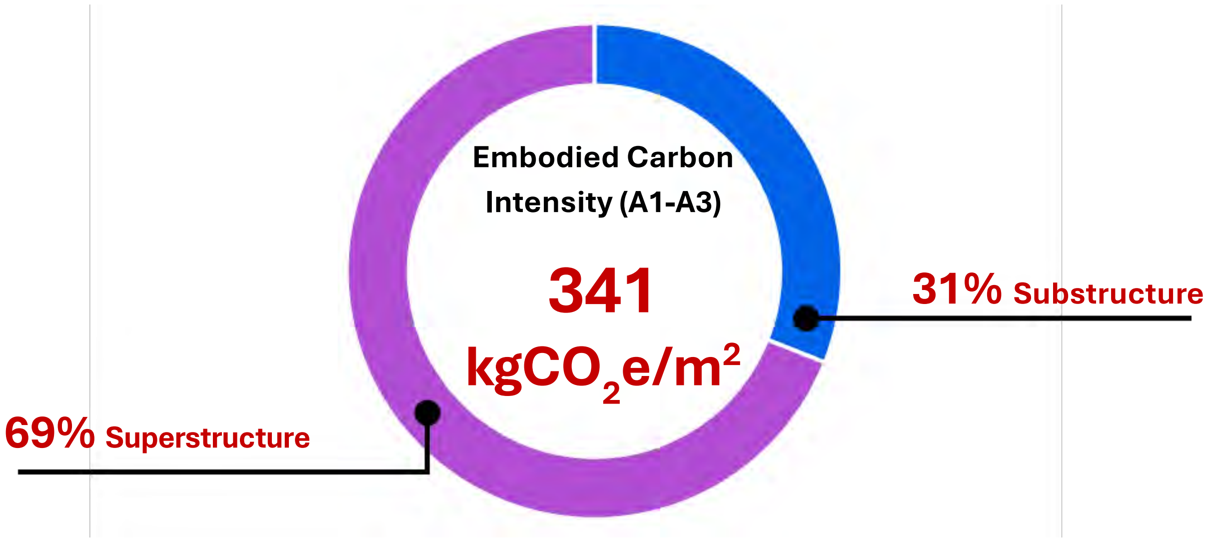
The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 54.9 kg/m^2 BUA

M7.5, M10, M30, and M40 grades of concrete have been used. 35% of the cement in all concrete grades has been replaced with GGBS.

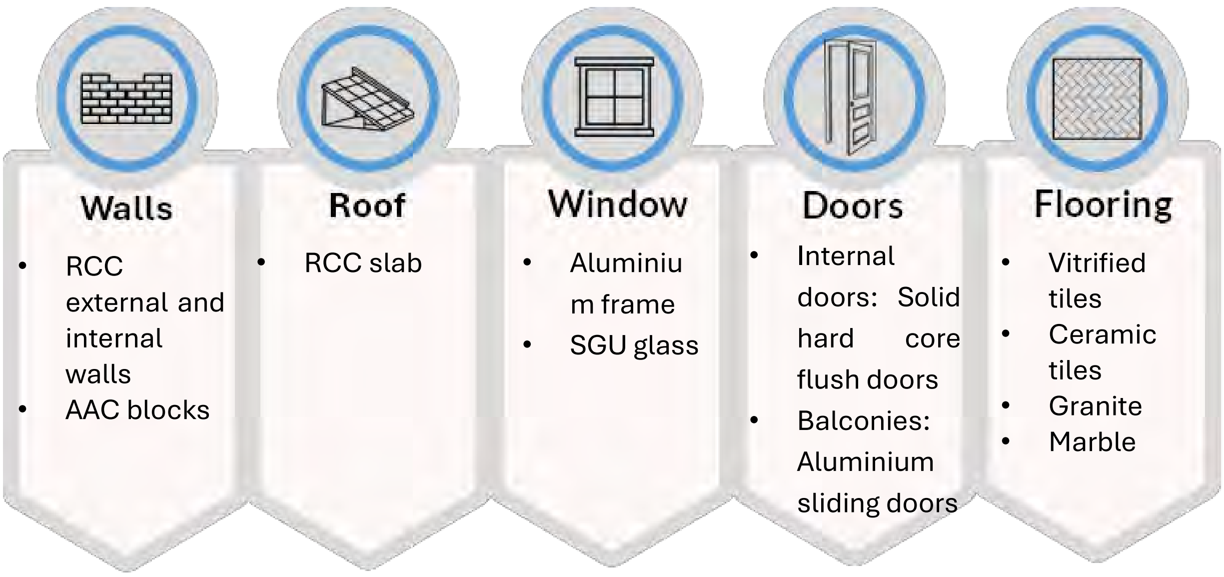
Concrete use intensity: 0.59 m^3/m^2 BUA

COMPONENT WISE EMISSIONS SHARE

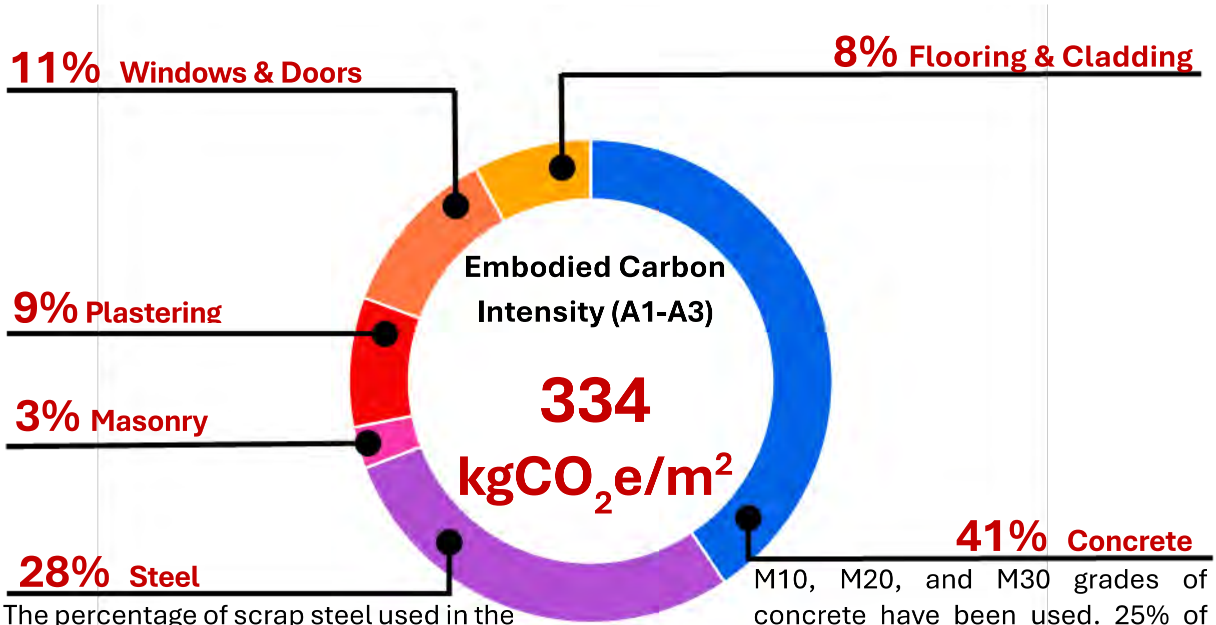


Building code: Z3-H-MC-O-1

Building location	Mumbai
Seismic zone	Zone 3
Height	High-rise
Structural system	Monolithic concrete
Parking	Open
Number of basements	0
Number of floors above ground	G+14
Built-up area (BUA) (m^2)	16989.00



PRODUCT WISE EMISSIONS SHARE



The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

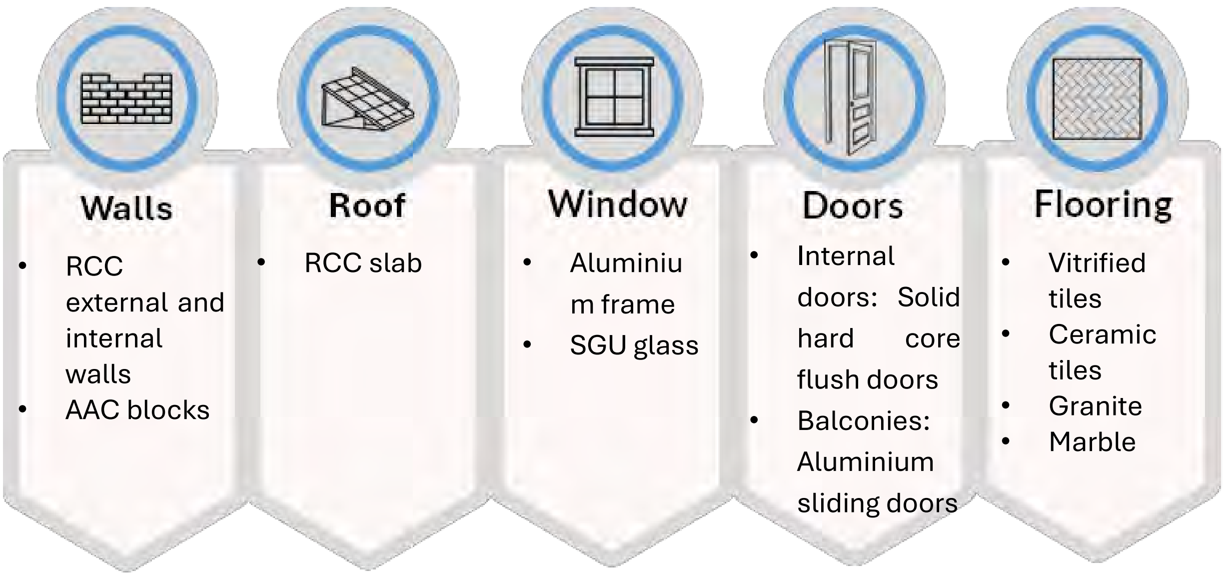
Steel use intensity: 33.85 kg/m^2 BUA

M10, M20, and M30 grades of concrete have been used. 25% of the cement in all concrete grades has been replaced with fly ash.

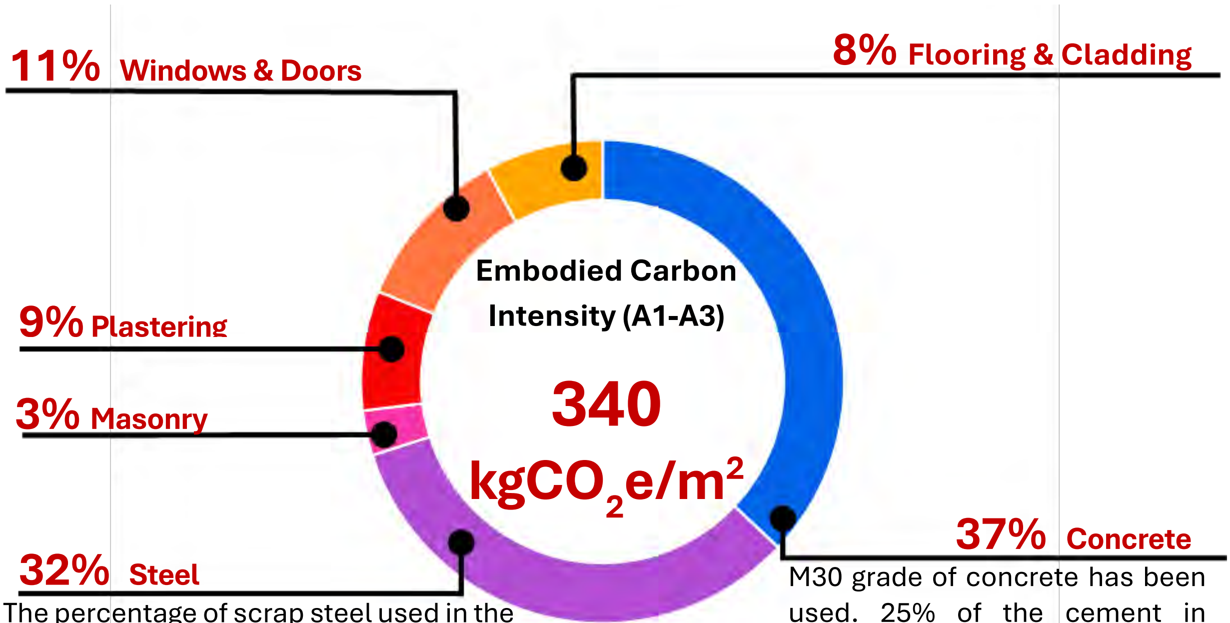
Concrete use intensity: 0.48 m^3/ m^2 BUA

Building code: Z3-H-MC-O-2

Building location	Mumbai
Seismic zone	Zone 3
Height	High-rise
Structural system	Monolithic concrete
Parking	Open
Number of basements	0
Number of floors above ground	G+18
Built-up area (BUA) (m2)	15984.00



PRODUCT WISE EMISSIONS SHARE



The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 39.48 kg/m^2 BUA

M30 grade of concrete has been used. 25% of the cement in concrete has been replaced with fly ash.

Concrete use intensity: 0.43 m^3/ m^2 BUA

Building code: Z3-H-MC-O-3

Building location	Mumbai
Seismic zone	Zone 3
Height	High-rise
Structural system	Monolithic concrete
Parking	Open
Number of basements	0
Number of floors above ground	G+23
Built-up area (BUA) (m2)	10424.00

Walls

- RCC external and internal walls
- AAC blocks

Roof

- RCC slab

Window

- Aluminium frame
- SGU glass

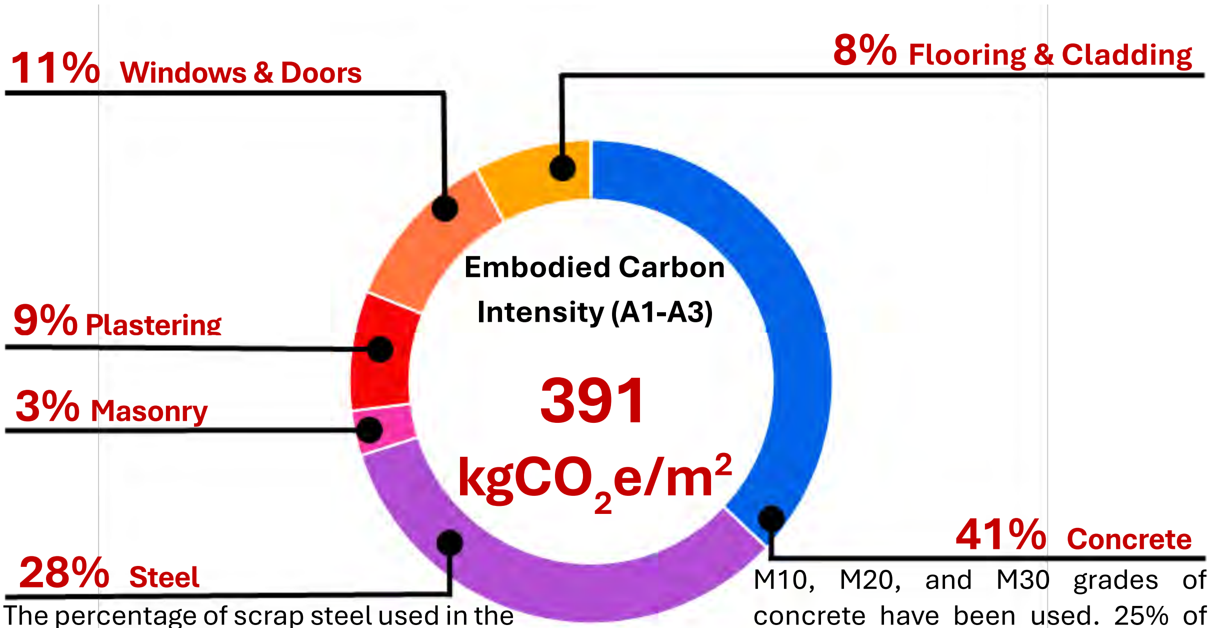
Doors

- Internal doors: Solid hard core flush doors
- Balconies: Aluminium sliding doors

Flooring

- Vitrified tiles
- Ceramic tiles
- Granite
- Marble

PRODUCT WISE EMISSIONS SHARE



The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

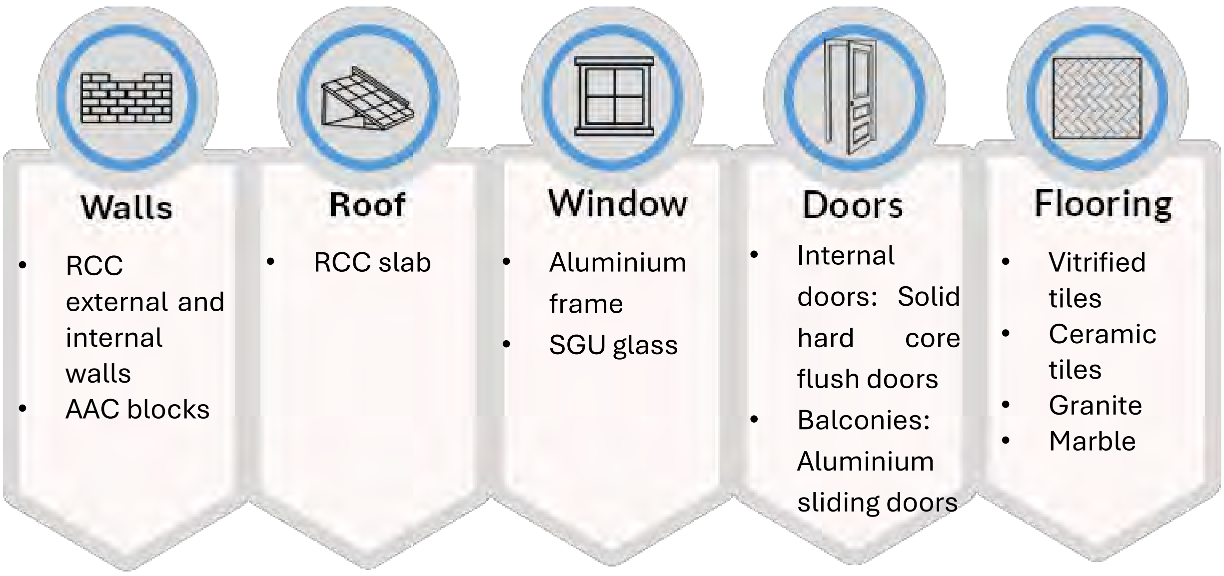
Steel use intensity: 33.85 kg/m^2 BUA

M10, M20, and M30 grades of concrete have been used. 25% of the cement in all concrete grades has been replaced with fly ash.

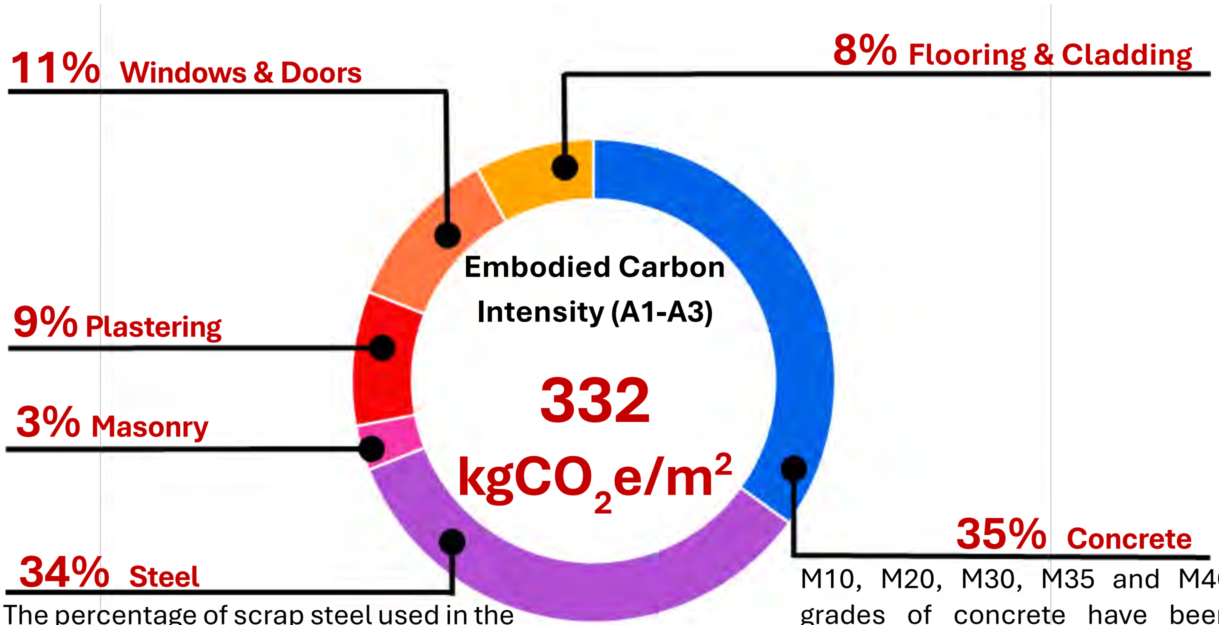
Concrete use intensity: 0.48 m^3/m^2 BUA

Building code: Z3-H-MC-O-4

Building location	Mumbai
Seismic zone	Zone 3
Height	High-rise
Structural system	Monolithic concrete
Parking	Open
Number of basements	0
Number of floors above ground	G+23
Built-up area (BUA) (m2)	10490.00



PRODUCT WISE EMISSIONS SHARE



The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

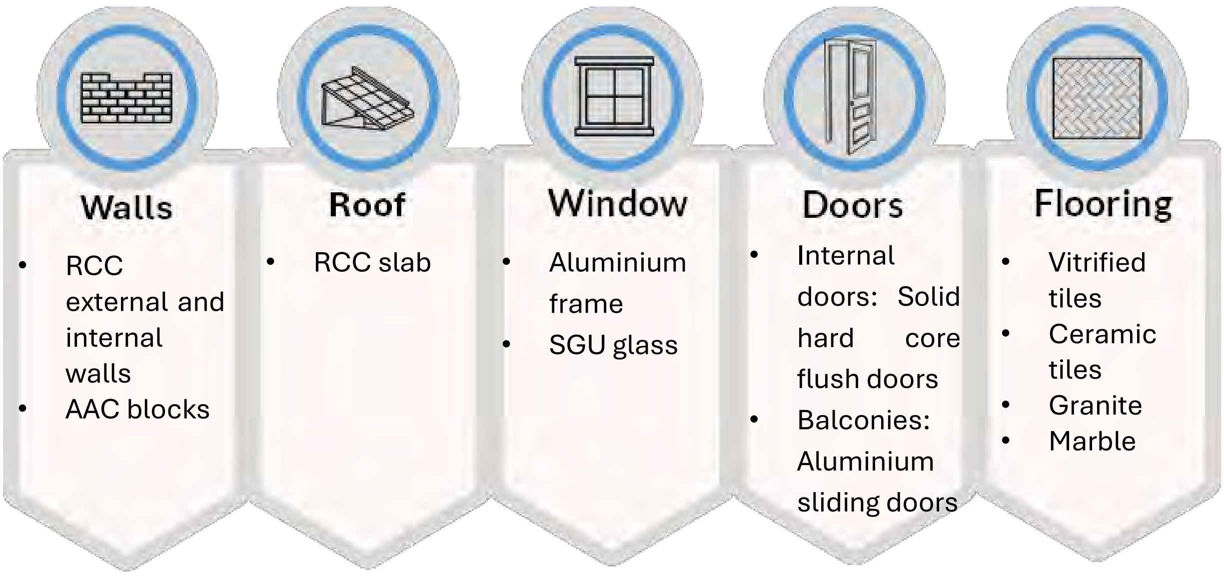
M10, M20, M30, M35 and M40 grades of concrete have been used. 45% of the cement in all concrete grades has been replaced with GGBS.

Steel use intensity: 40.66 kg/m^2 BUA

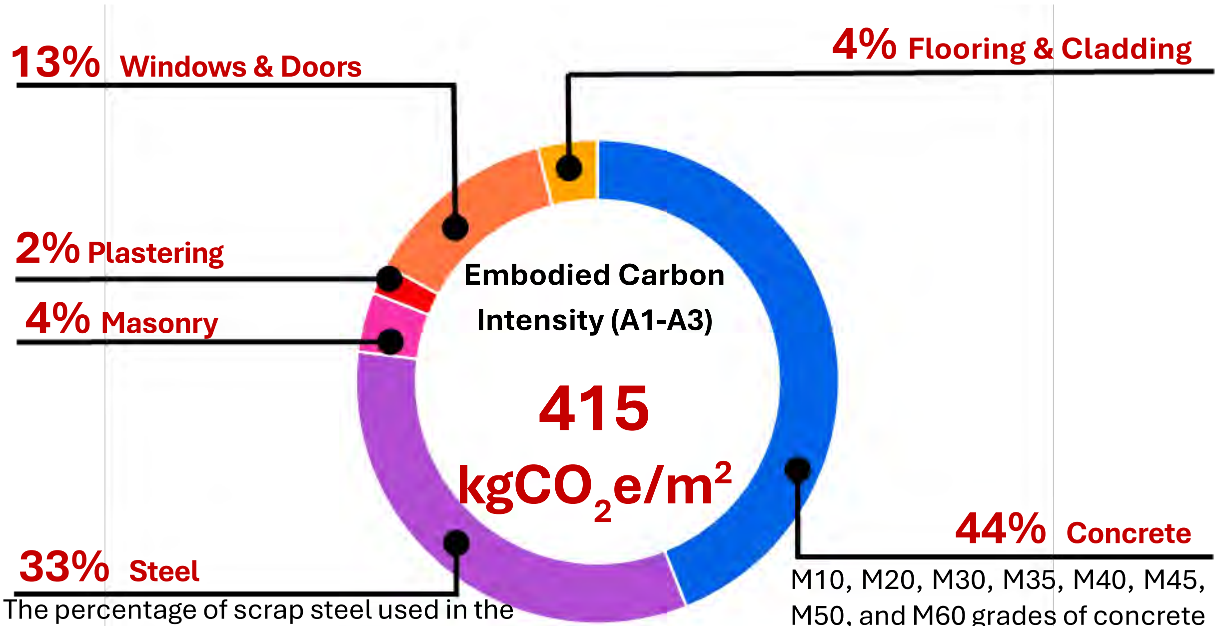
Concrete use intensity: 0.50 m^3/m^2 BUA

Building code: Z3-H-MC-O-5

Building location	Mumbai
Seismic zone	Zone 3
Height	High-rise
Structural system	Monolithic concrete
Parking	Open
Number of basements	0
Number of floors above ground	G+35
Built-up area (BUA) (m2)	32150.00



PRODUCT WISE EMISSIONS SHARE



The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 49.02 kg/m^2 BUA

M10, M20, M30, M35, M40, M45, M50, and M60 grades of concrete have been used. 25% of the cement in all concrete grades has been replaced with flyash.

Concrete use intensity: 0.59 m^3/m^2 BUA

Building code: Z3-H-MC-O-6

Building location	Mumbai
Seismic zone	Zone 3
Height	High-rise
Structural system	Monolithic concrete
Parking	Open
Number of basements	0
Number of floors above ground	G+39
Built-up area (BUA) (m2)	34617.00

Walls

- RCC external and internal walls
- AAC blocks
-

Roof

- RCC slab

Window

- Aluminium frame
- SGU glass

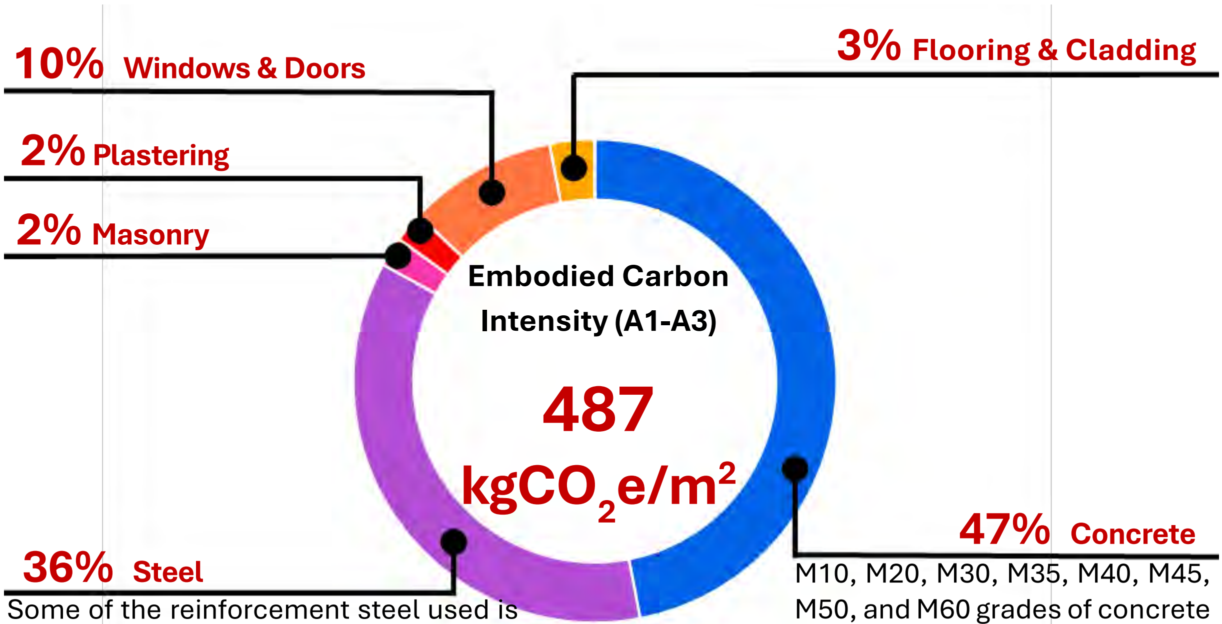
Doors

- Internal doors: Solid hard core flush doors
- Balconies: Aluminium sliding doors

Flooring

- Vitrified tiles
- Ceramic tiles
- Granite
- Marble

PRODUCT WISE EMISSIONS SHARE



Some of the reinforcement steel used is virgin steel i.e. 0% scrap. For the remaining steel quantity, 40% scrap percentage considered.

Steel use intensity: 61.24 kg/m^2 BUA

M10, M20, M30, M35, M40, M45, M50, and M60 grades of concrete have been used. 25% of the cement in all concrete grades has been replaced with flyash.

Concrete use intensity: 0.73 m^3/ m^2 BUA

Building code: Z3-H-MC-O-7

Building location	Mumbai
Seismic zone	Zone 3
Height	High-rise
Structural system	Monolithic concrete
Parking	Open
Number of basements	0
Number of floors above ground	G+40
Built-up area (BUA) (m2)	43965.00

Walls

- RCC external and internal walls
- AAC blocks
-

Roof

- RCC slab

Window

- Aluminium frame
- SGU glass

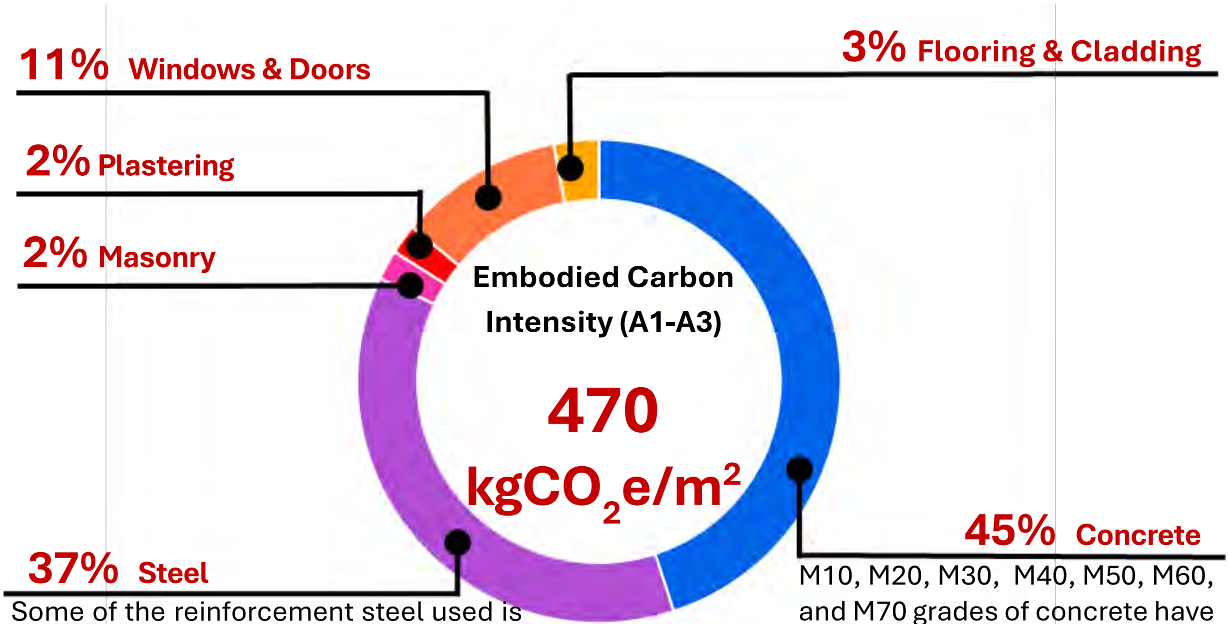
Doors

- Internal doors: Solid hard core flush doors
- Balconies: Aluminium sliding doors

Flooring

- Vitrified tiles
- Ceramic tiles
- Granite
- Marble

PRODUCT WISE EMISSIONS SHARE



Some of the reinforcement steel used is virgin steel i.e. 0% scrap. For the remaining steel quantity, 40% scrap percentage considered.

Steel use intensity: 59.55 kg/m^2 BUA

M10, M20, M30, M40, M50, M60, and M70 grades of concrete have been used. 25% of the cement in all concrete grades has been replaced with flyash.

Concrete use intensity: 0.59 m^3/ m^2 BUA

Building code: Z3-H-MC-O-8

Building location	Mumbai
Seismic zone	Zone 3
Height	High-rise
Structural system	Monolithic concrete
Parking	Open
Number of basements	0
Number of floors above ground	G+40
Built-up area (BUA) (m2)	29091.00

Walls

- RCC external and internal walls
- AAC blocks

Roof

- RCC slab

Window

- Aluminium frame
- SGU glass

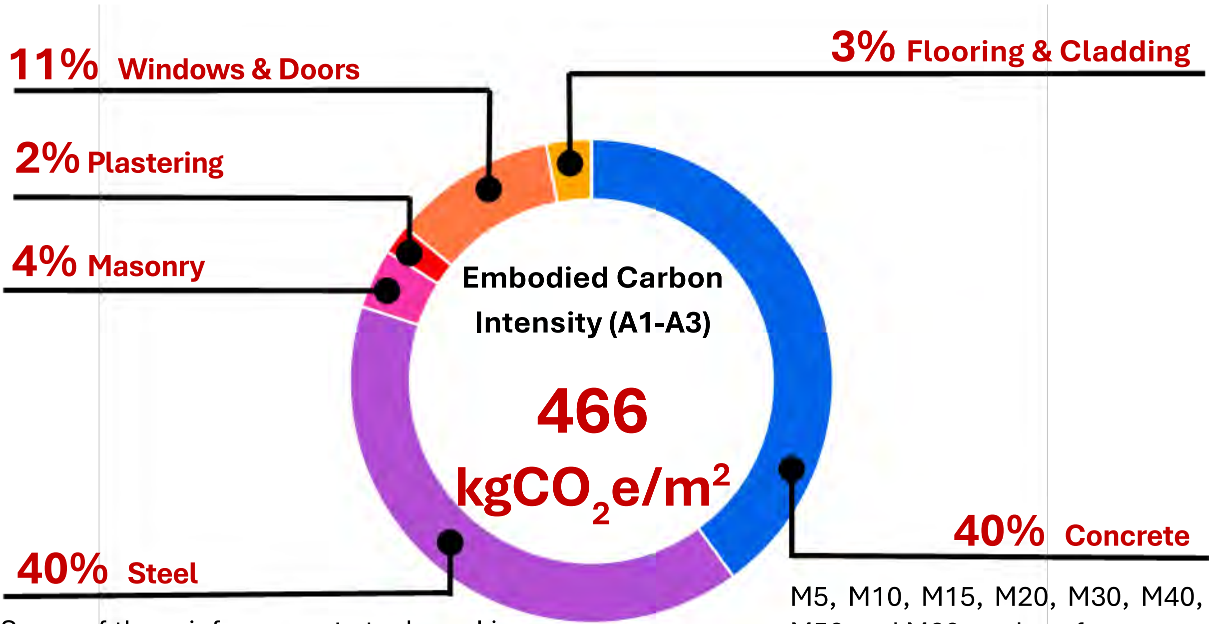
Doors

- Internal doors: Solid hard core flush doors
- Balconies: Aluminium sliding doors

Flooring

- Vitrified tiles
- Ceramic tiles
- Granite
- Marble

PRODUCT WISE EMISSIONS SHARE



Some of the reinforcement steel used is virgin steel i.e. 0% scrap. For the remaining steel quantity, 40% scrap percentage considered.

Steel use intensity: 64.37 kg/m^2 BUA

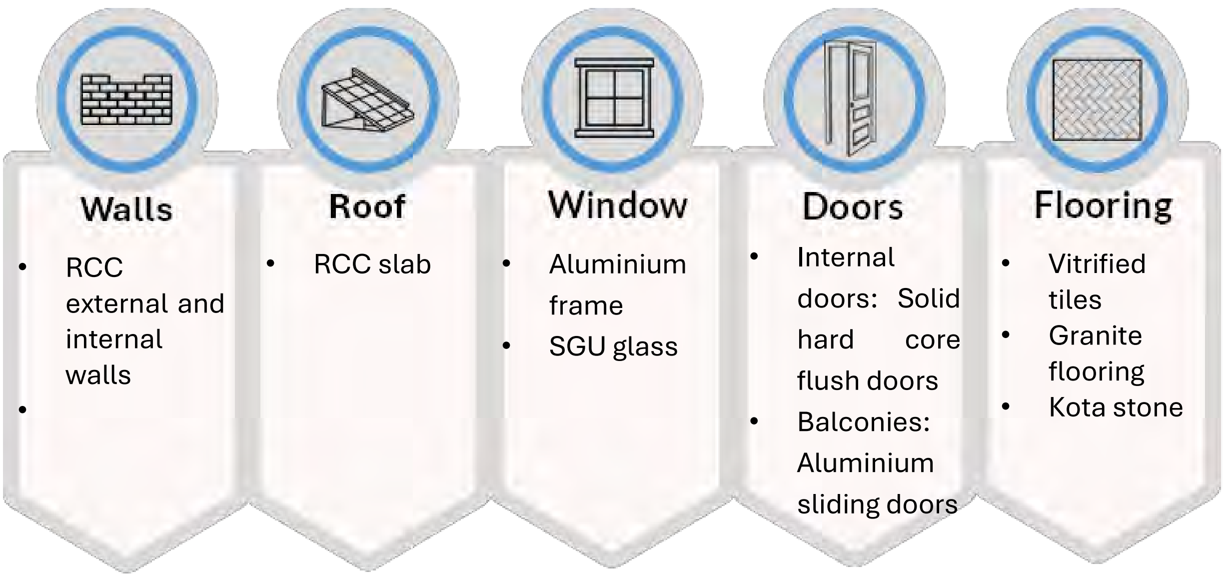
M5, M10, M15, M20, M30, M40, M50 and M60 grades of concrete have been used. 25% of the cement in all concrete grades has been replaced with flyash.

Concrete use intensity: 0.60 m^3/m^2 BUA

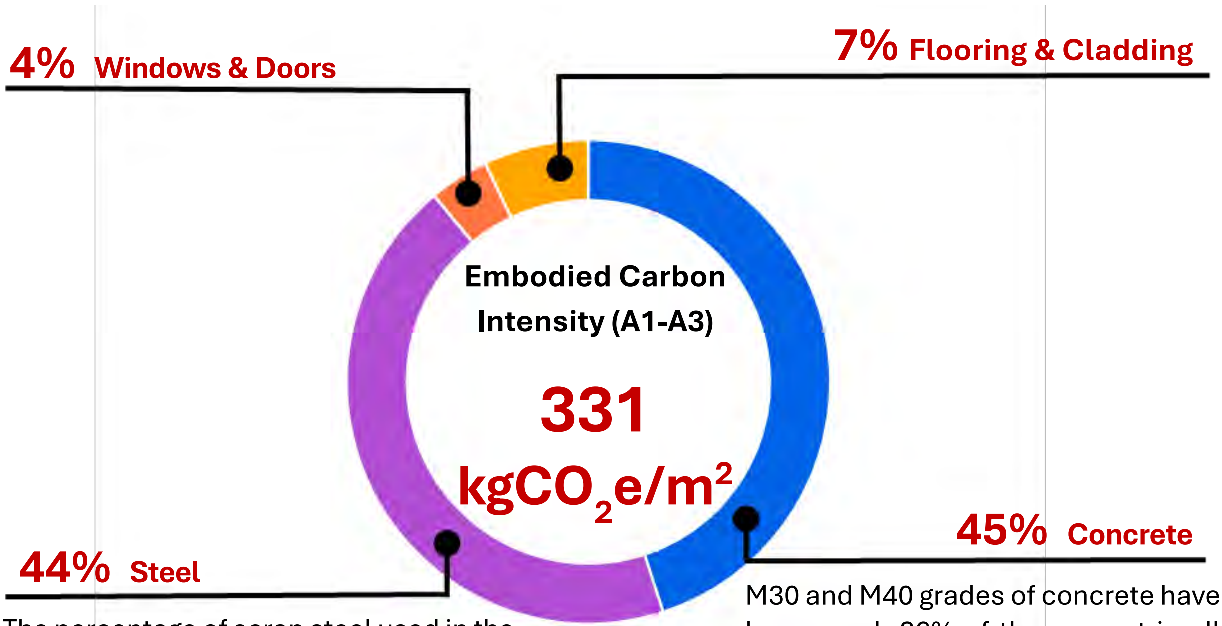
Building code: Z3-H-MC-P-1

High-rise residential project consists of four residential towers (16 storeys), and two-levels of podium with no basement underneath.

Building location	Pune
Seismic zone	Zone 3
Height	High-rise
Structural system	Monolithic concrete
Parking	Podium
Foundation type	Raft footings
Number of basements	0
Number of floors above ground	2P+G+13
Built-up area (BUA) (m2)	49537.30



PRODUCT WISE EMISSIONS SHARE



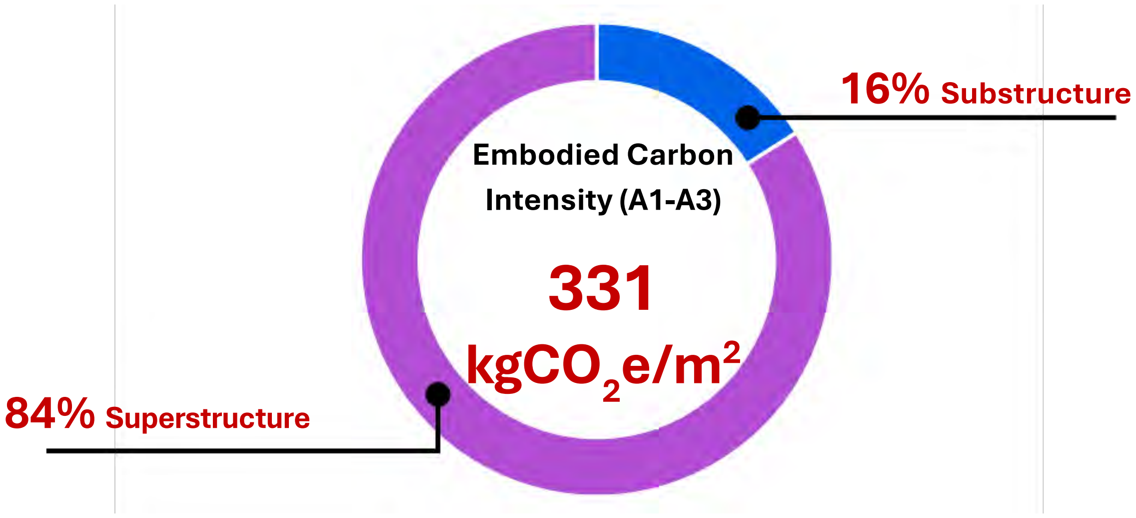
The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 51.64 kg/m^2 BUA

M30 and M40 grades of concrete have been used. 26% of the cement in all concrete grades has been replaced with flyash.

Concrete use intensity: 0.44 m^3/m^2 BUA

COMPONENT WISE EMISSIONS SHARE



Building code: Z3-M-MC-O-1

Building location	Mumbai
Seismic zone	Zone 3
Height	Mid-rise
Structural system	Monolithic concrete
Parking	Open
Number of basements	0
Number of floors above ground	G+10
Built-up area (BUA) (m2)	8026.00

Walls
- RCC external and internal walls
- AAC blocks

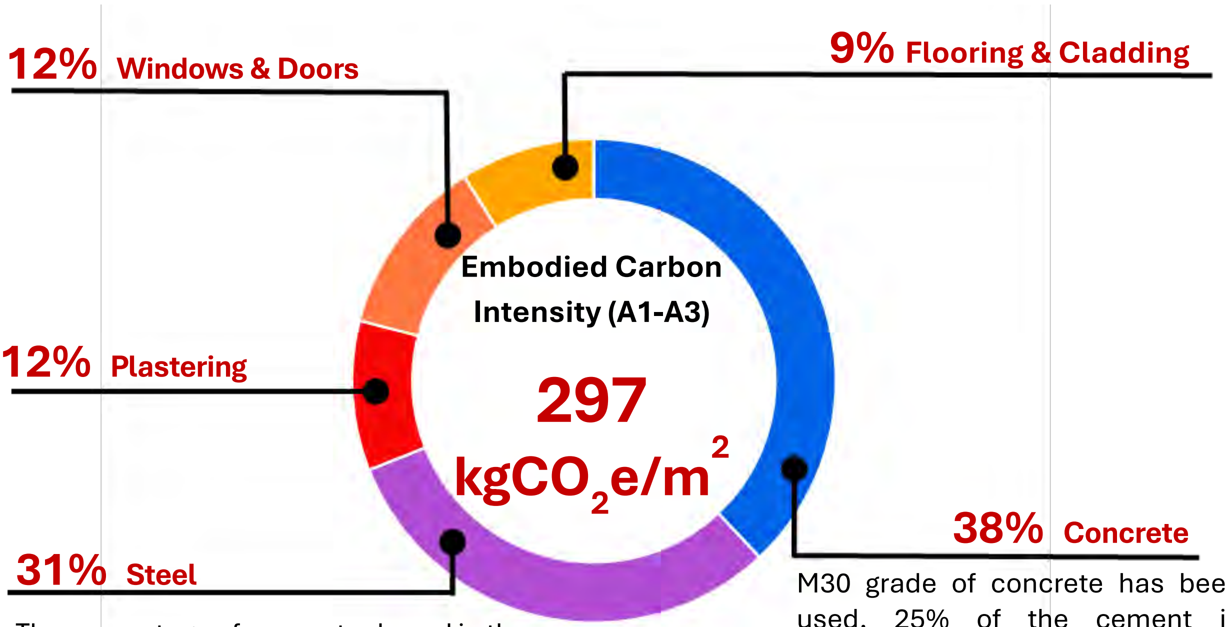
Roof
- RCC slab

Window
- Aluminium frame
- SGU glass

Doors
- Internal doors: Solid hard core flush doors
- Balconies: Aluminium sliding doors

Flooring
- Vitrified tiles
- Ceramic tiles
- Granite
- Marble

PRODUCT WISE EMISSIONS SHARE



The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 32.89 kg/m^2 BUA

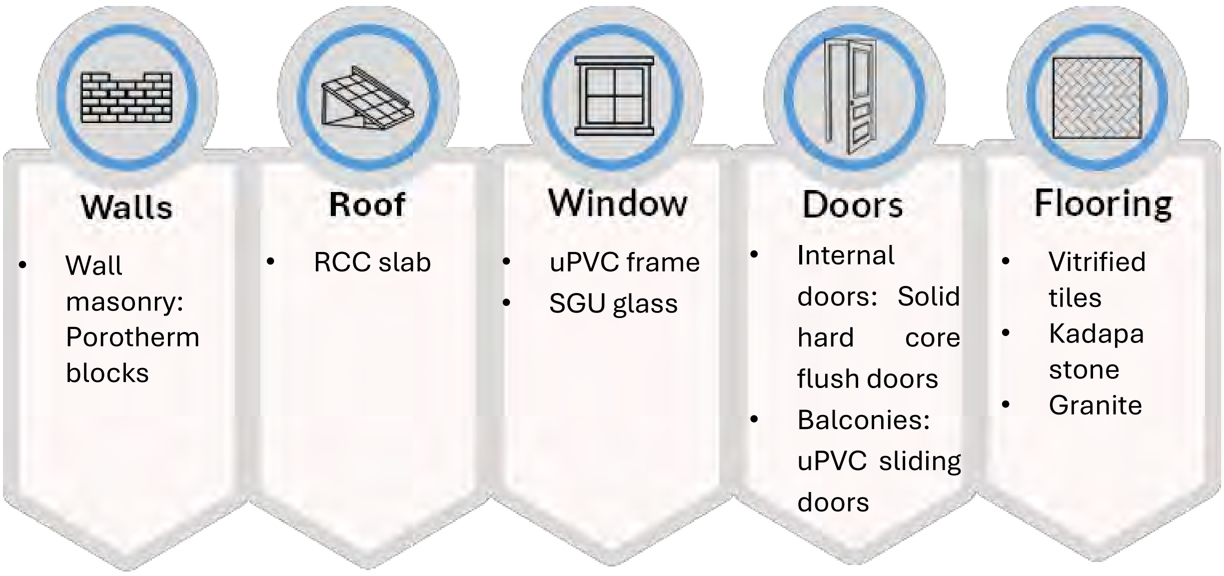
M30 grade of concrete has been used. 25% of the cement in concrete has been replaced with fly ash.

Concrete use intensity: 0.39 m^3/ m^2 BUA

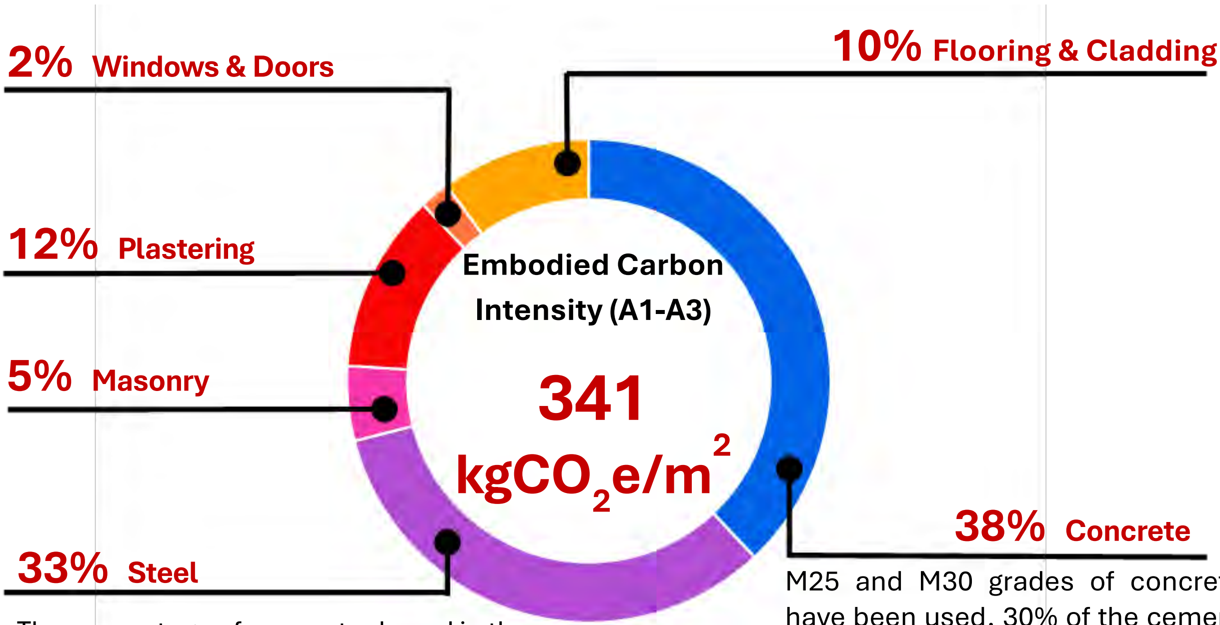
Building code: Z2-H-RF-B-1

High-rise residential project consists of five residential towers (12 storeys), a clubhouse, and a two-level basement underneath and two-level of podium.

Building location	Hyderabad
Seismic zone	Zone 2
Height	High-rise
Structural system	Reinforced framed structure
Parking	Basement
Foundation type	Isolated column footings
Number of basements	2
Number of floors above ground	2P+12
Built-up area (BUA) (m2)	128040.45



PRODUCT WISE EMISSIONS SHARE



The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 39.73 kg/m^2 BUA

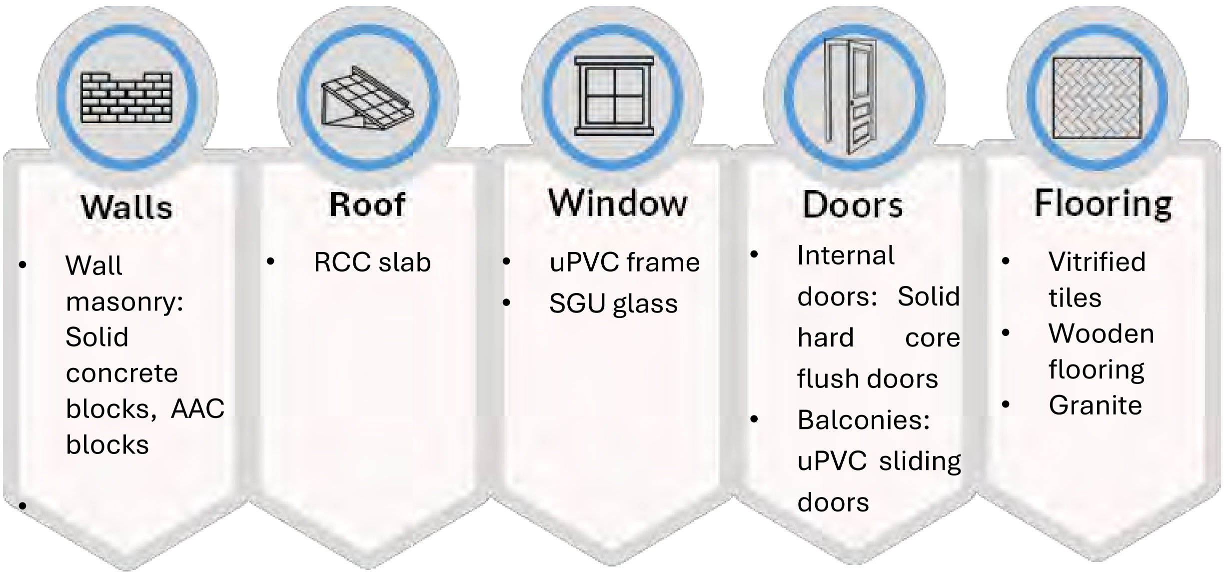
M25 and M30 grades of concrete have been used. 30% of the cement in all concrete grades has been replaced with fly ash.

Concrete use intensity: 0.46 m^3/m^2 BUA

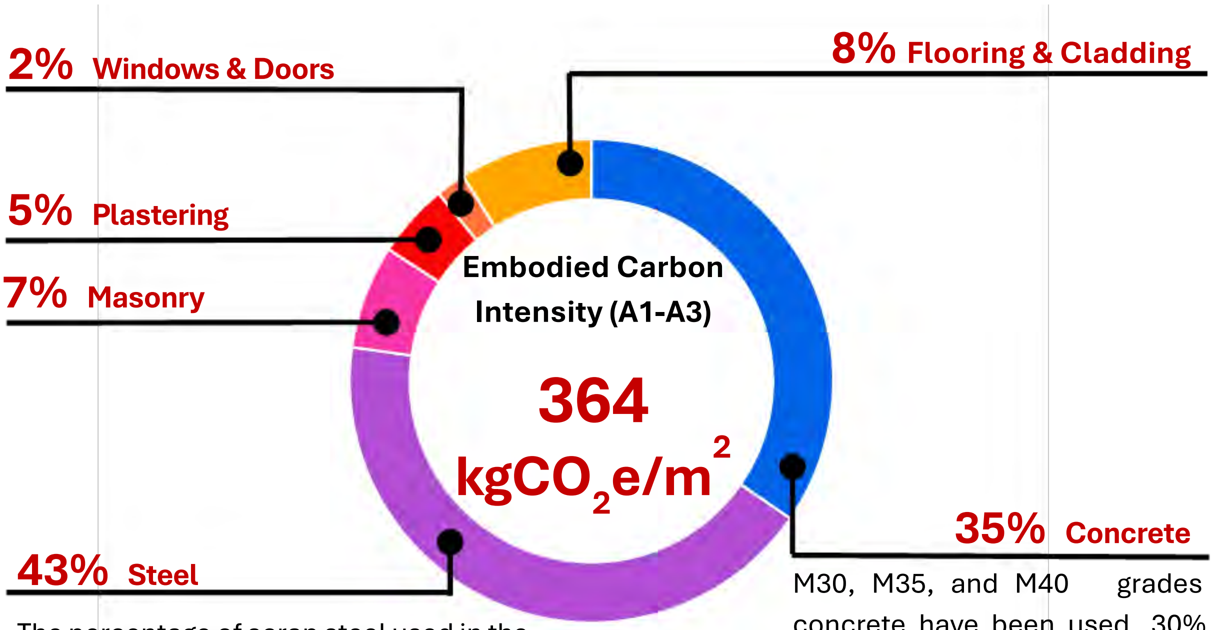
Building code: Z2-H-RF-B-2

High-rise residential project consists of three cluster of residential towers (15 storeys), a clubhouse, and a two-level basement underneath.

Building location	Bengaluru
Seismic zone	Zone 2
Height	High-rise
Structural system	Reinforced framed structure
Parking	Basement
Foundation type	Raft and isolated column footings
Number of basements	2
Number of floors above ground	G+14
Built-up area (BUA) (m2)	142990.31



PRODUCT WISE EMISSIONS SHARE



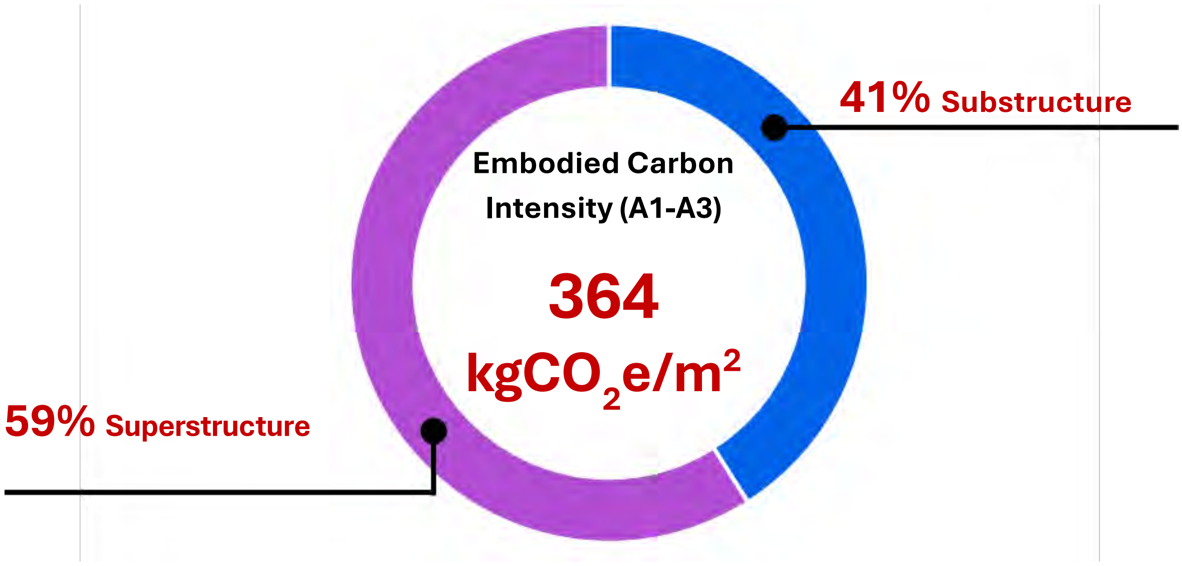
The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 56.19 kg/m^2 BUA

M30, M35, and M40 grades of concrete have been used. 30% of the cement in all concrete grades has been replaced with fly ash.

Concrete use intensity: 0.47 m^3/m^2 BUA

COMPONENT WISE EMISSIONS SHARE



Building code: Z2-H-RF-S-1

Mid-rise residential project with terrace gardens within each apartment. It consists of one residential tower (15 storeys), indoor amenities, and no basement.

Building location	Bengaluru
Seismic zone	Zone 2
Height	High-rise
Structural system	Reinforced framed structure
Parking	Stilt
Foundation type	Combined and isolated column footings
Number of basements	2
Number of floors above ground	S+G+12
Built-up area (BUA) (m2)	49541.36

Walls
- Wall masonry: Solid concrete blocks

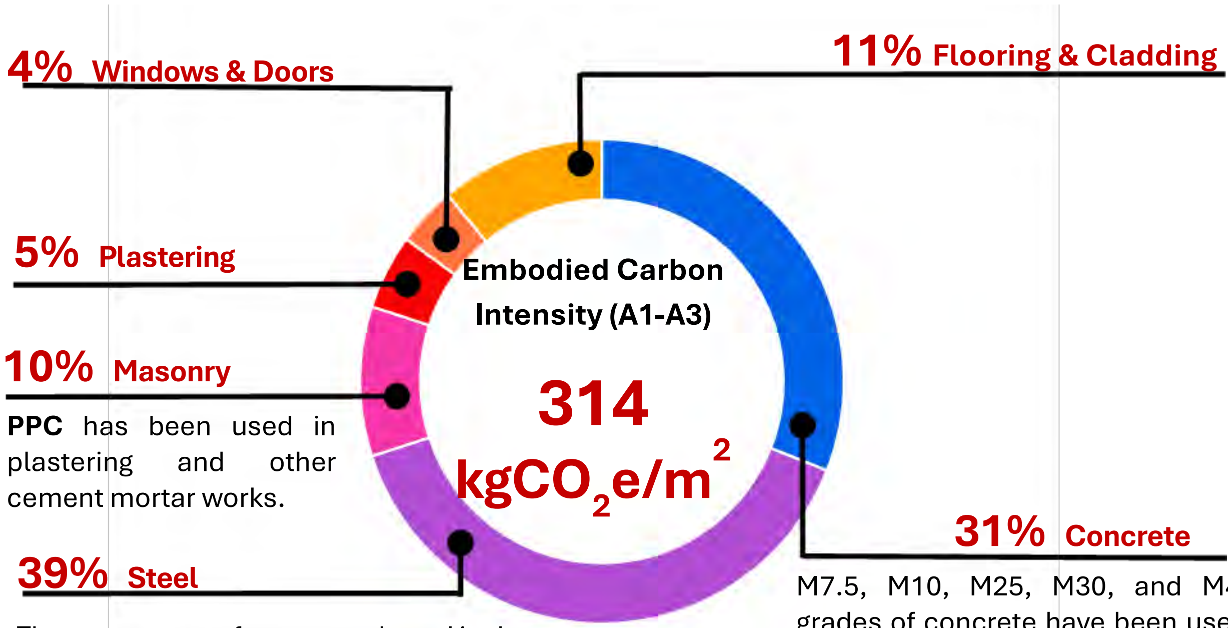
Roof
- RCC slab

Window
- uPVC frame
- SGU glass

Doors
- Internal doors: Solid hard core flush doors
- Balconies: uPVC sliding doors

Flooring
- Vitrified tiles
- Ceramic tiles
- Granite

PRODUCT WISE EMISSIONS SHARE



PPC has been used in plastering and other cement mortar works.

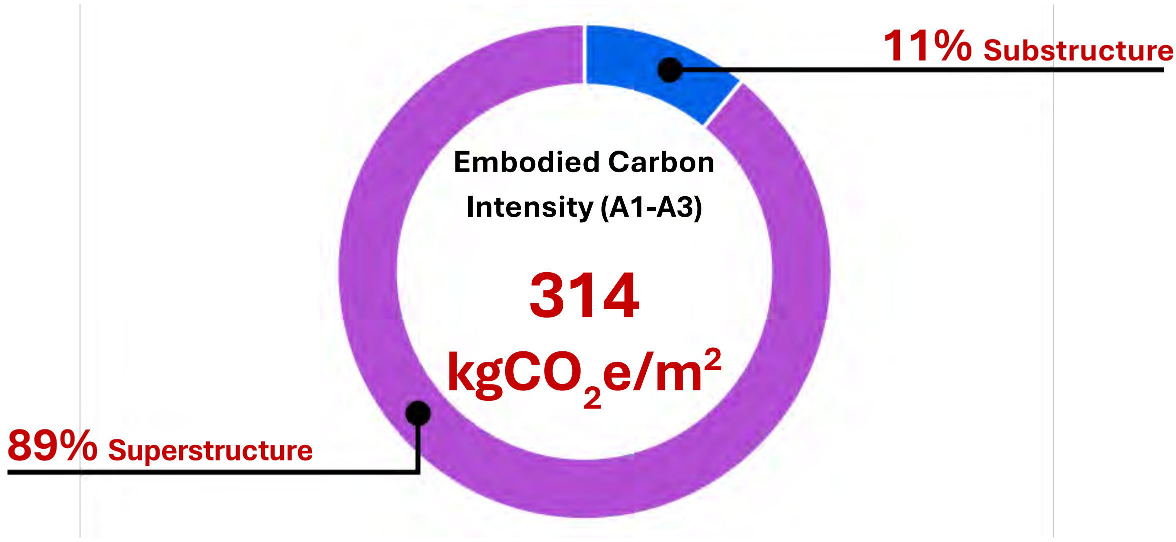
The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 43.22 kg/m^2 BUA

M7.5, M10, M25, M30, and M40 grades of concrete have been used. 30% of the cement in all concrete grades has been replaced with GGBS.

Concrete use intensity: 0.39 m^3/m^2 BUA

COMPONENT WISE EMISSIONS SHARE



Building code: Z3-H-RF-P-1

Mid-rise residential project consists of four residential towers (14 storeys), a clubhouse, and no basement.

Building location	Kochi
Seismic zone	Zone 3
Height	High-rise
Structural system	Reinforced framed structure
Parking	Podium
Foundation type	Pile
Number of basements	0
Number of floors above ground	P+G+14
Built-up area (BUA) (m2)	17034.27

Walls

- Wall Masonry: Hurdi block, Porotherm blocks

Roof

- RCC slab

Window

- Aluminium frame
- SGU glass

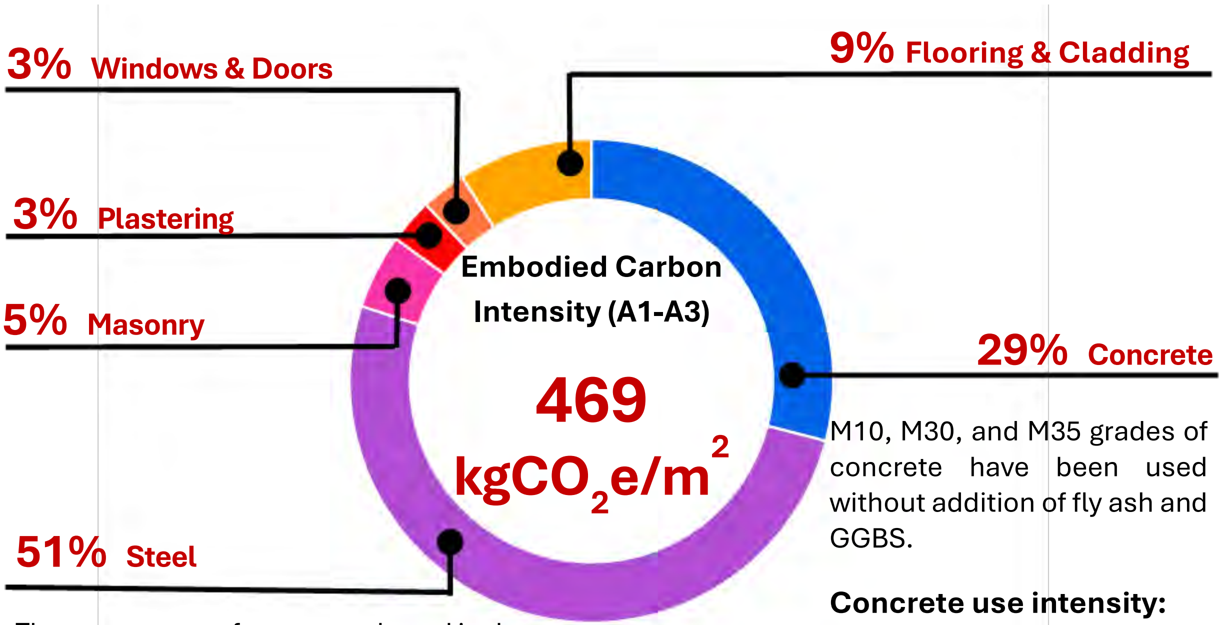
Doors

- Internal doors: Solid hard core flush doors
- Balconies: Aluminium sliding doors

Flooring

- Vitrified tiles

PRODUCT WISE EMISSIONS SHARE



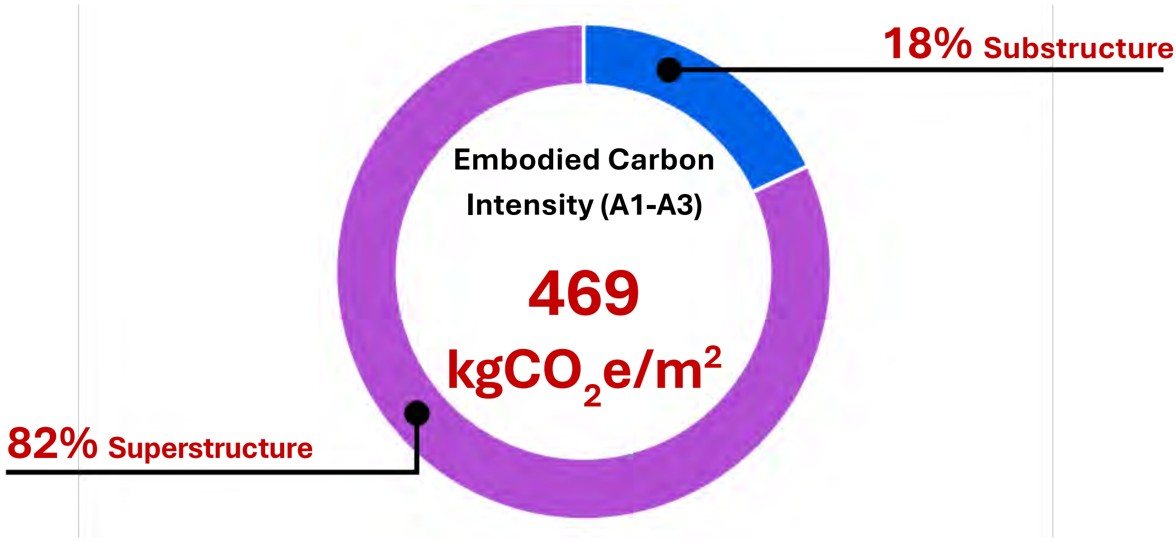
The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 84.99 kg/m^2 BUA

M10, M30, and M35 grades of concrete have been used without addition of fly ash and GGBS.

Concrete use intensity: 0.37 m^3/m^2 BUA

COMPONENT WISE EMISSIONS SHARE



Building code: Z2-M-RF-B-1

Mid-rise residential project consists of one residential tower (11 storeys), a clubhouse, and one basement underneath.

Building location	Bengaluru
Seismic zone	Zone 2
Height	Mid-rise
Structural system	Reinforced framed structure
Parking	Basement
Foundation type	Isolated column footings
Number of basements	1
Number of floors above ground	G+10
Built-up area (BUA) (m2)	12831.83

Walls

- Wall masonry: AAC blocks

Roof

- RCC slab

Window

- Aluminium frame
- SGU glass

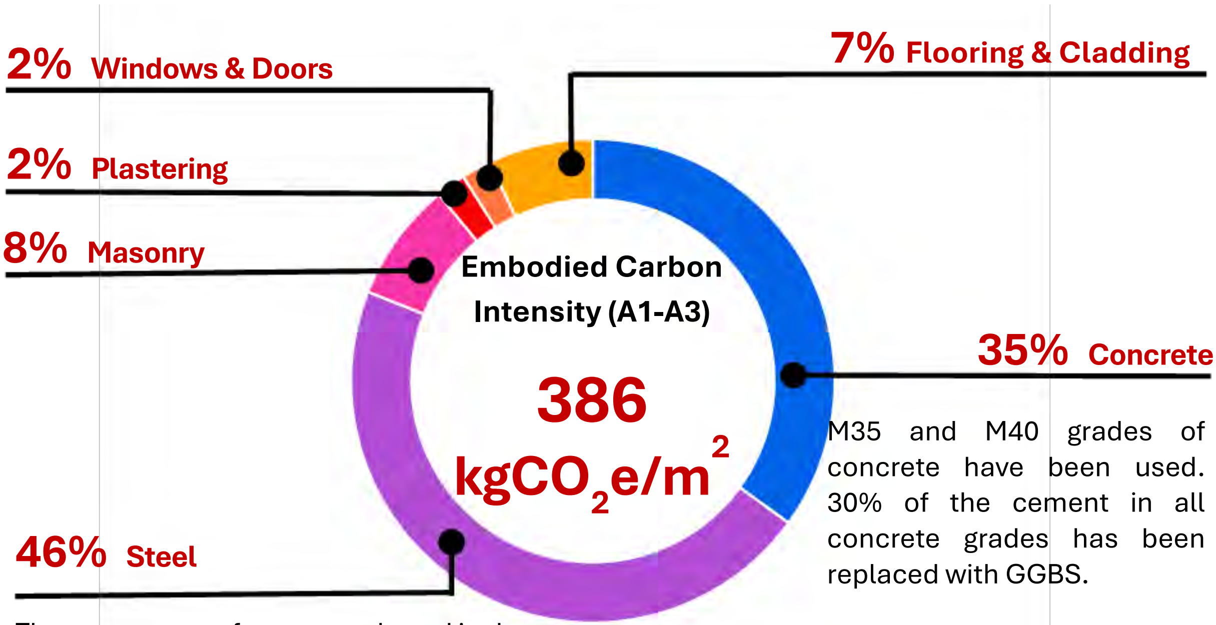
Doors

- Internal doors: Solid hard core flush doors
- Balconies: Aluminium sliding doors

Flooring

- Vitrified tiles
- Wood flooring
- Granite flooring

PRODUCT WISE EMISSIONS SHARE



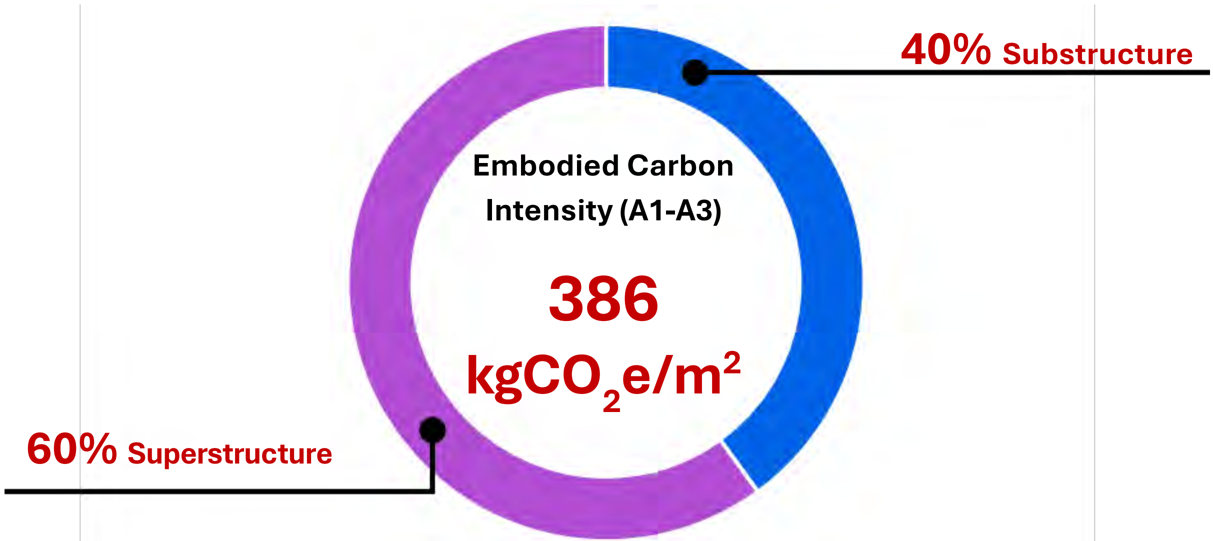
M35 and M40 grades of concrete have been used. 30% of the cement in all concrete grades has been replaced with GGBS.

Concrete use intensity: 0.47 m^3/m^2 BUA

The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 63.98 kg/m^2 BUA

COMPONENT WISE EMISSIONS SHARE



Building code: Z2-M-RF-B-2

Mid-rise residential project consists of one residential tower (12 storeys), a clubhouse, and two basements underneath.

Building location	Bengaluru
Seismic zone	Zone 2
Height	Mid-rise
Structural system	Reinforced framed structure
Parking	Basement
Foundation type	Isolated column footings
Number of basements	2
Number of floors above ground	G+11
Built-up area (BUA) (m2)	40868.68

Walls
- Wall masonry: AAC blocks, Solid concrete blocks

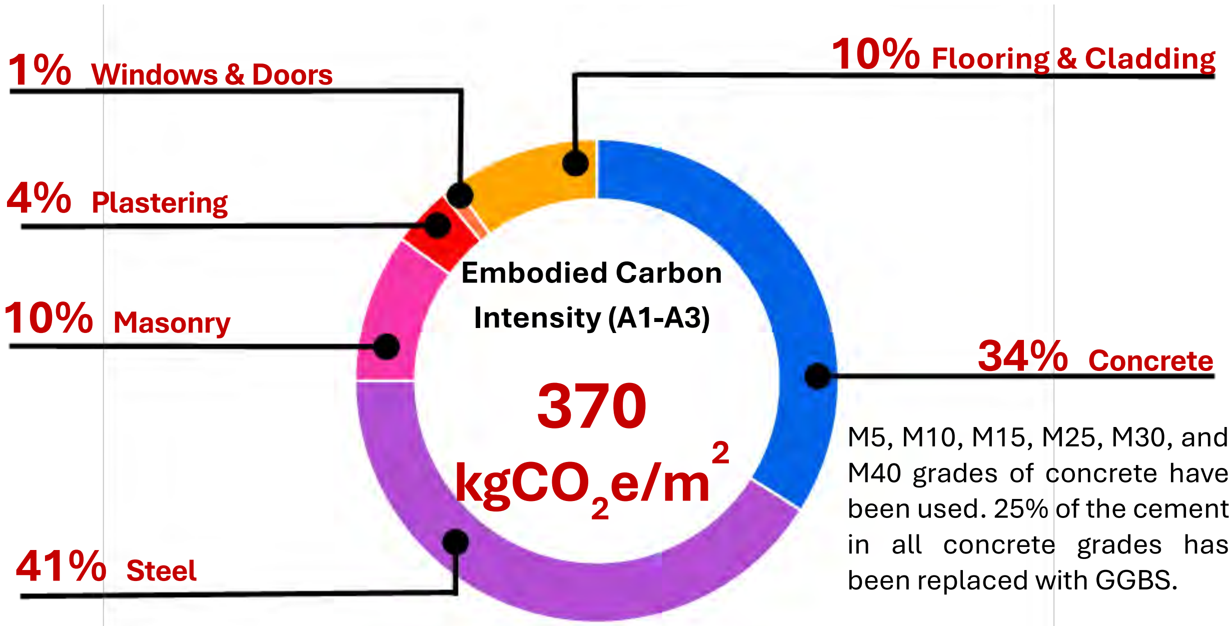
Roof
- RCC slab

Window
- uPVC frame
- SGU glass

Doors
- Internal doors: Solid hard core flush doors
- Balconies: uPVC sliding doors

Flooring
- Vitrified tiles
- Cement based tiles

PRODUCT WISE EMISSIONS SHARE



The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 54.01 kg/m^2 BUA

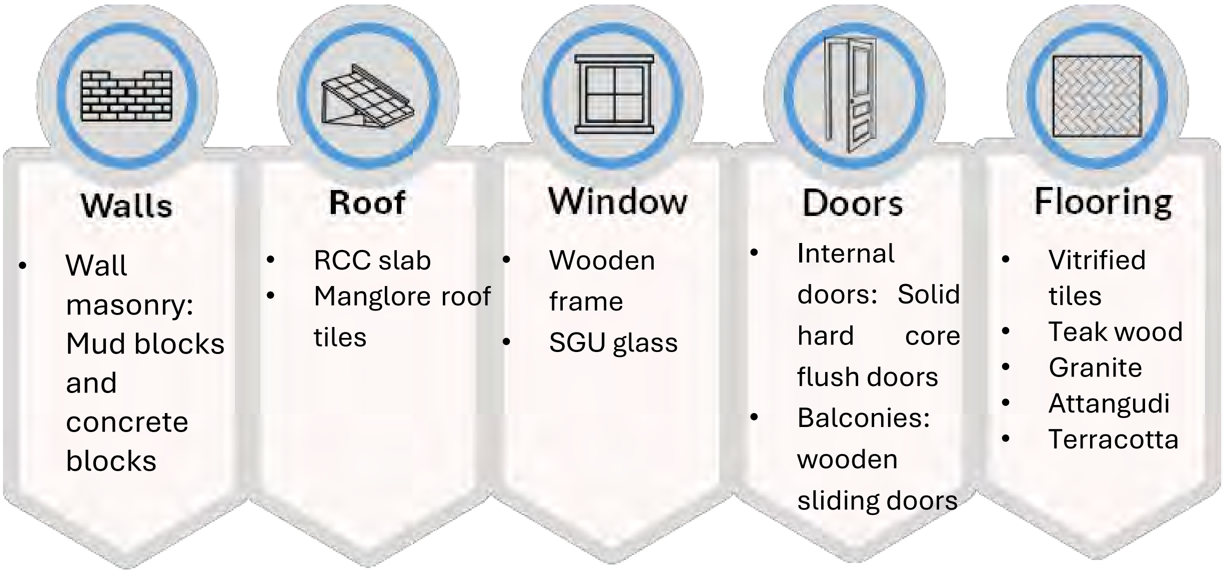
M5, M10, M15, M25, M30, and M40 grades of concrete have been used. 25% of the cement in all concrete grades has been replaced with GGBS.

Concrete use intensity: 0.45 m^3/m^2 BUA

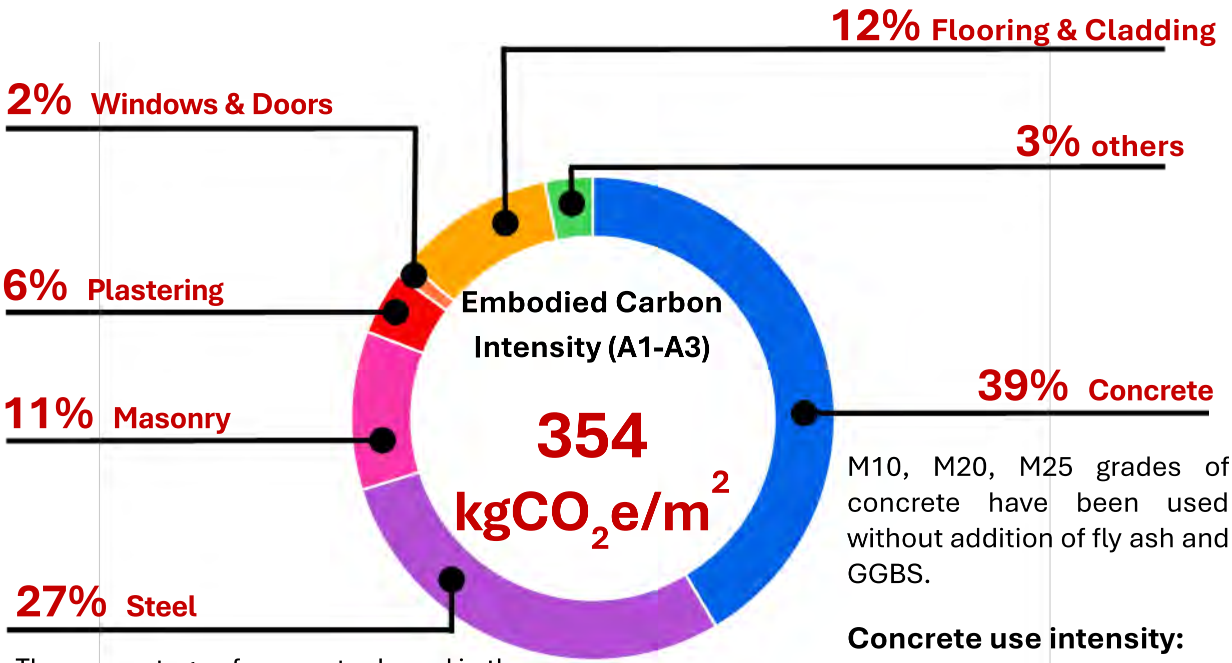
Building code: Z2-L-RF-B-1

Low-rise residential project consists of townhouses (2 storeys), a clubhouse, and a one-level basement underneath.

Building location	Bengaluru
Seismic zone	Zone 2
Height	Low-rise
Structural system	Reinforced framed structure
Parking	Basement
Foundation type	Hybrid: Pile & Combined Footing
Number of basements	Peripheral Houses: 1 Podium Houses: 0
Number of floors above ground	G+1
Built-up area (BUA) (m2)	25,628.54



PRODUCT WISE EMISSIONS SHARE



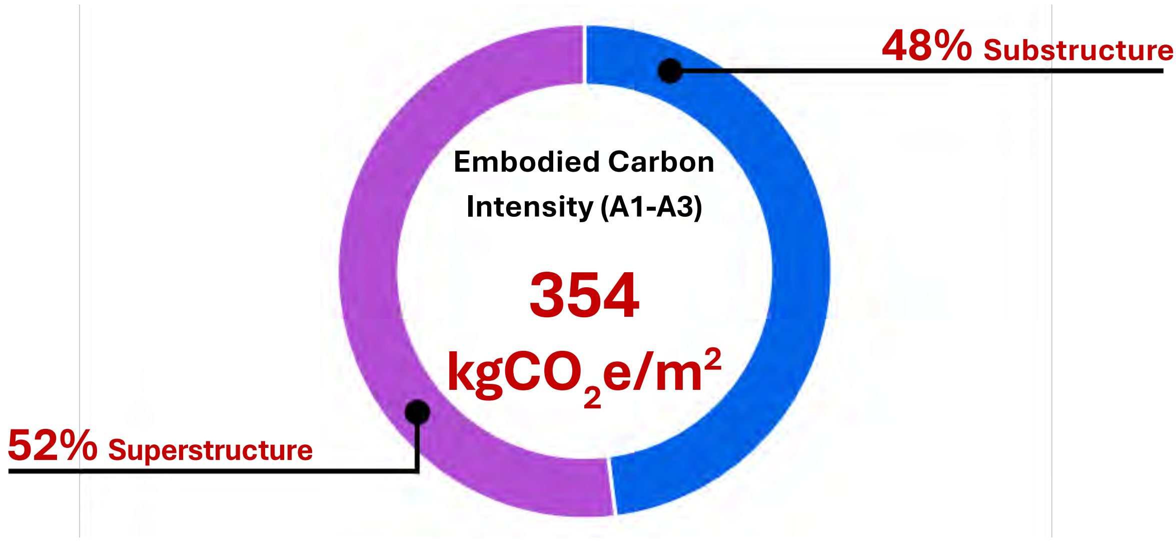
M10, M20, M25 grades of concrete have been used without addition of fly ash and GGBS.

Concrete use intensity: 0.41 m^3/m^2 BUA

The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 34.47 kg/m^2 BUA

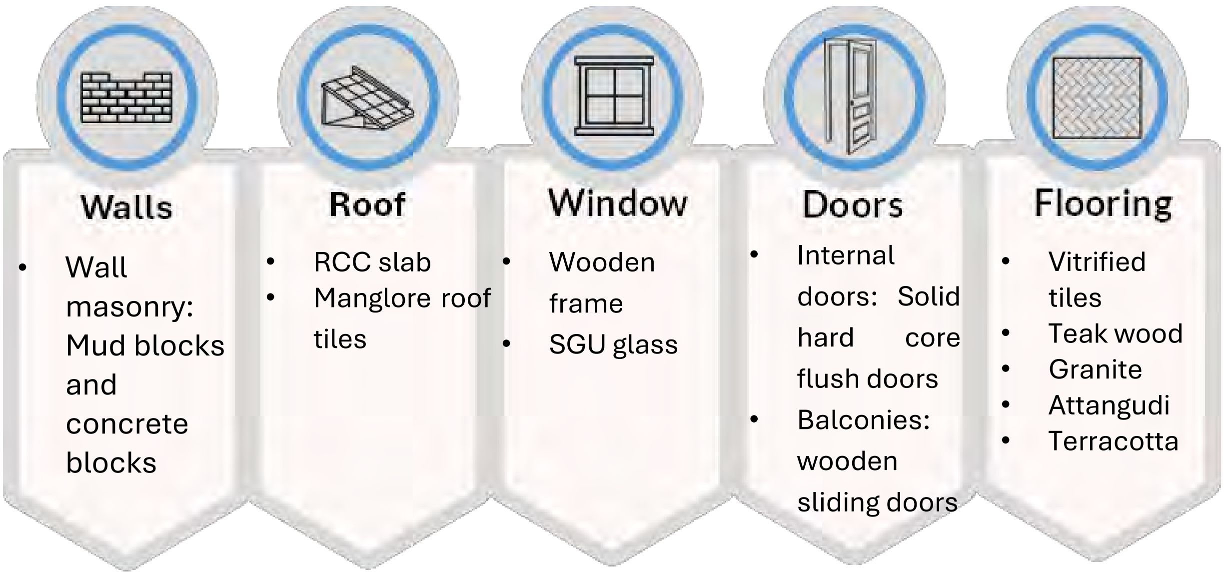
COMPONENT WISE EMISSIONS SHARE



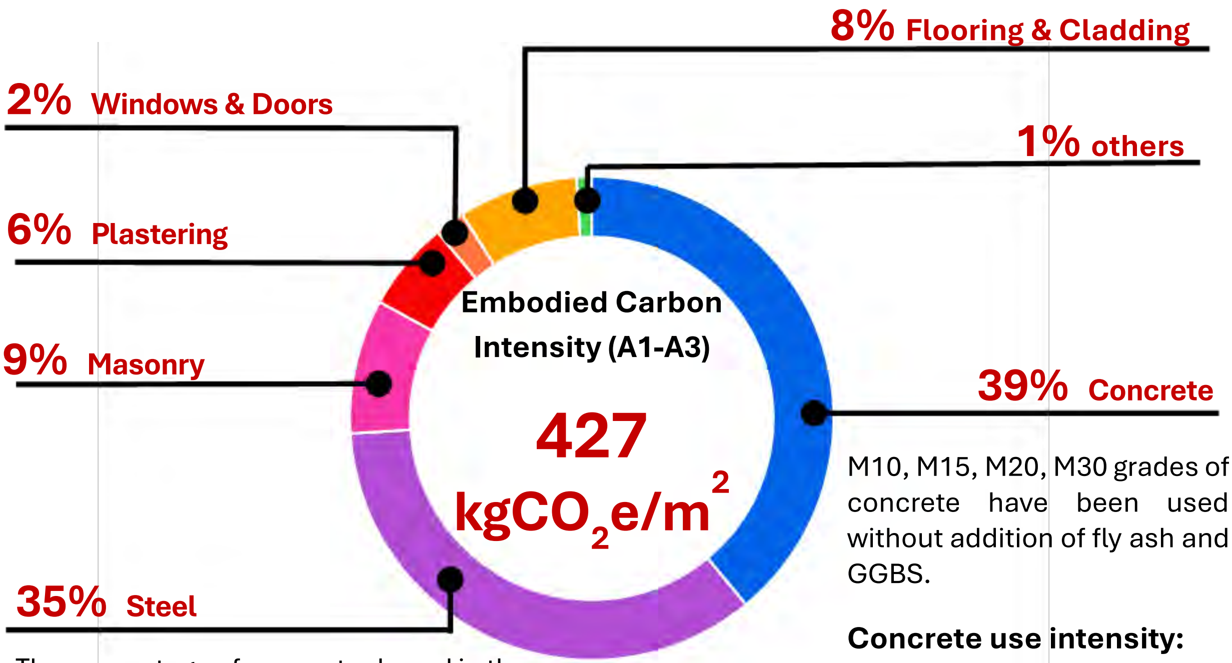
Building code: Z2-L-RF-B-2

Mid-rise residential project consists of townhouses, villament walkups and one residential tower, a clubhouse, and two-level of basement underneath.

Building location	Bengaluru
Seismic zone	Zone 2
Height	Low-rise
Structural system	Reinforced framed structure
Parking	Basement
Foundation type	Isolated column footings
Number of basements	2
Number of floors above ground	G+11
Built-up area (BUA) (m2)	23,856.65



PRODUCT WISE EMISSIONS SHARE



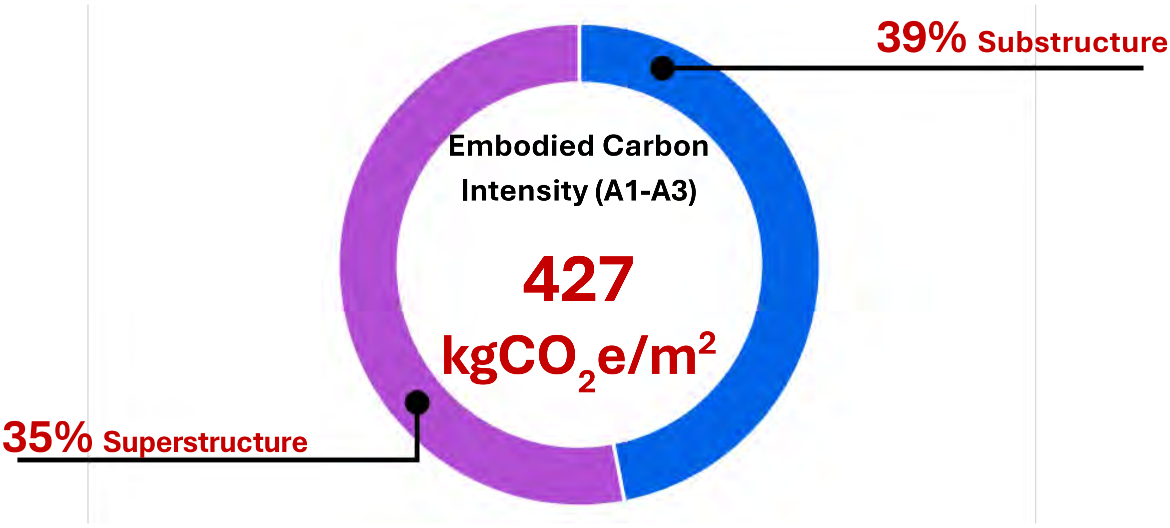
M10, M15, M20, M30 grades of concrete have been used without addition of fly ash and GGBS.

Concrete use intensity: 0.41 m^3/m^2 BUA

The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 62.55 kg/m^2 BUA

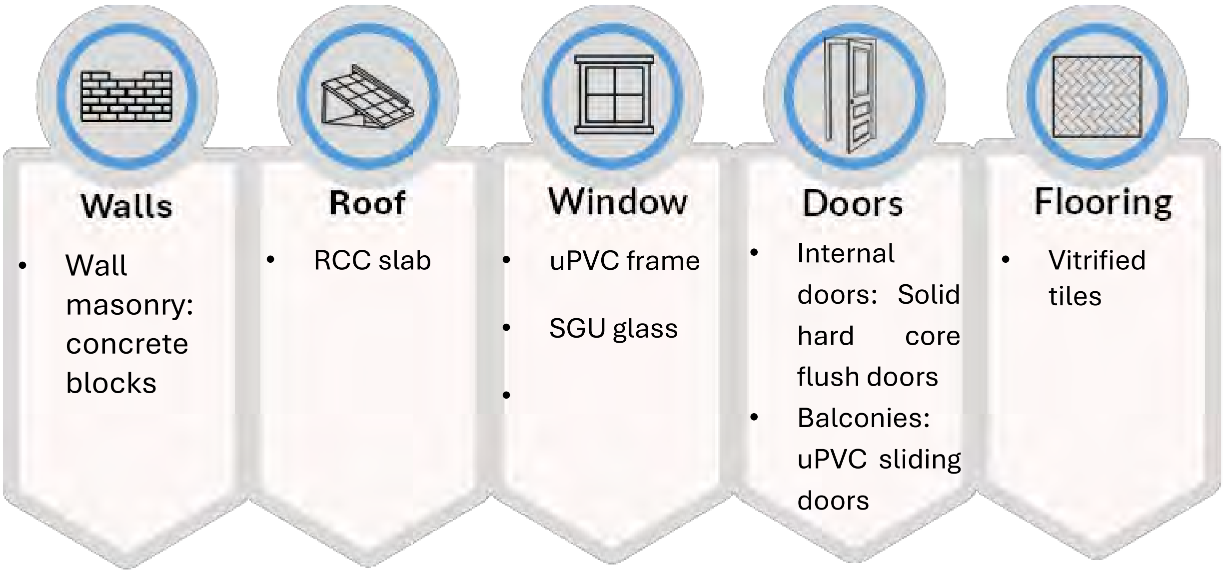
COMPONENT WISE EMISSIONS SHARE



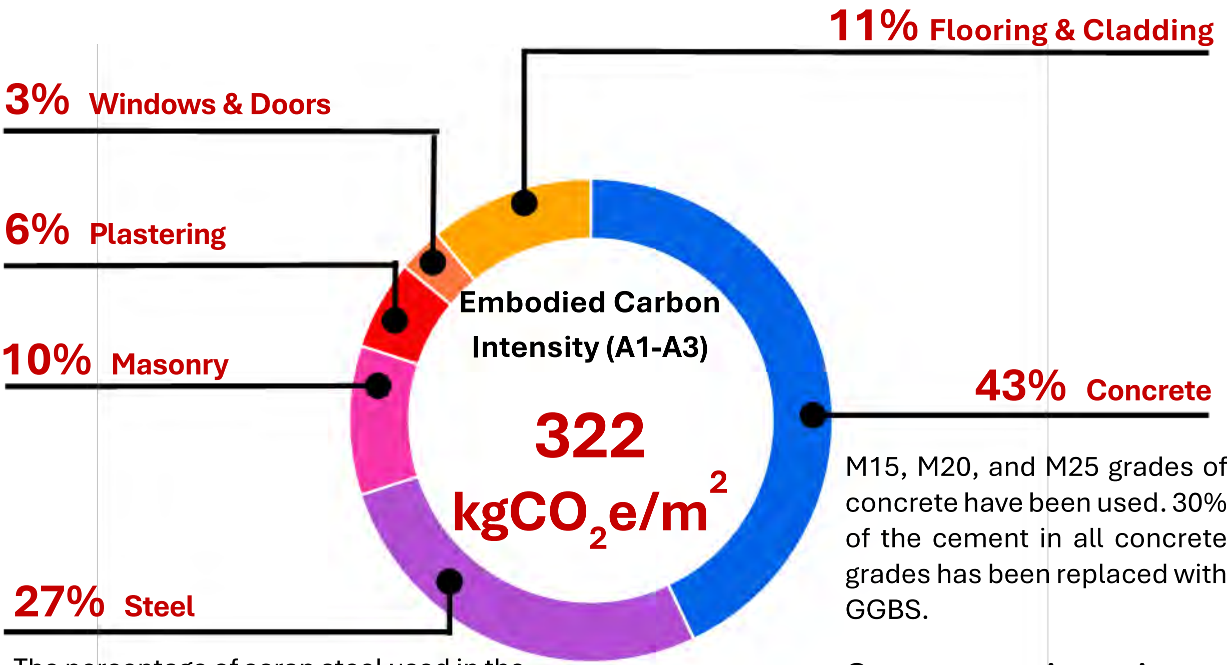
Building code: Z2-L-RF-O-1

Low-rise residential project consists of 2 storeys villas, a clubhouse, and no basement.

Building location	Bengaluru
Seismic zone	Zone 2
Height	Low-rise
Structural system	Reinforced framed structure
Parking	Open
Foundation type	Isolated column footings
Number of basements	0
Number of floors above ground	G+1
Built-up area (BUA) (m2)	75377.00



PRODUCT WISE EMISSIONS



The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 31.39 kg/m^2 BUA

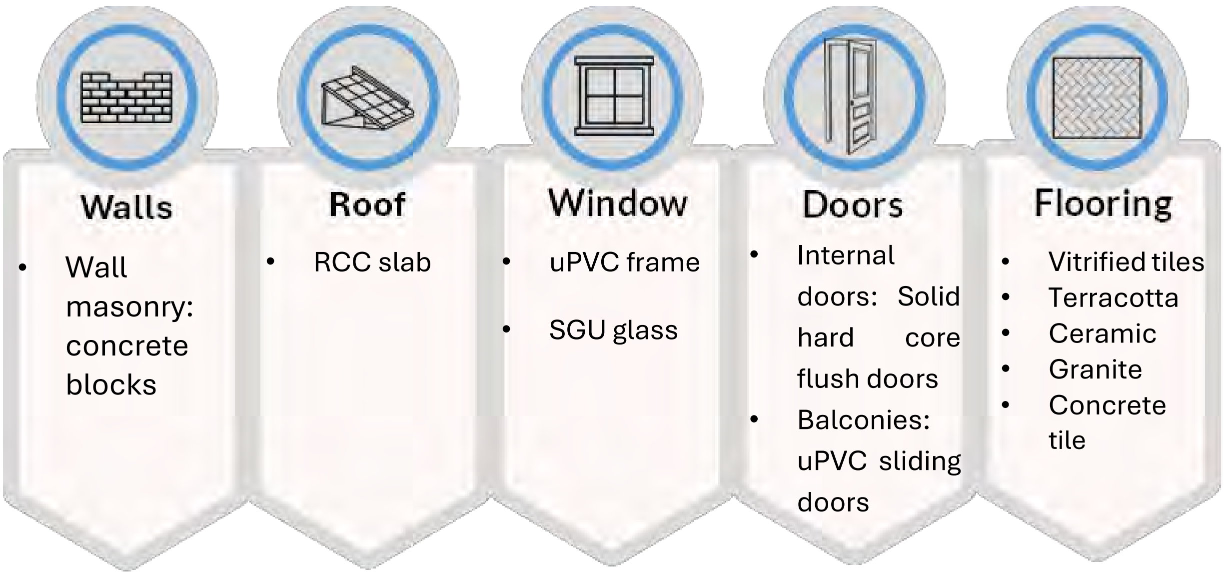
M15, M20, and M25 grades of concrete have been used. 30% of the cement in all concrete grades has been replaced with GGBS.

Concrete use intensity: 0.36 m^3/m^2 BUA

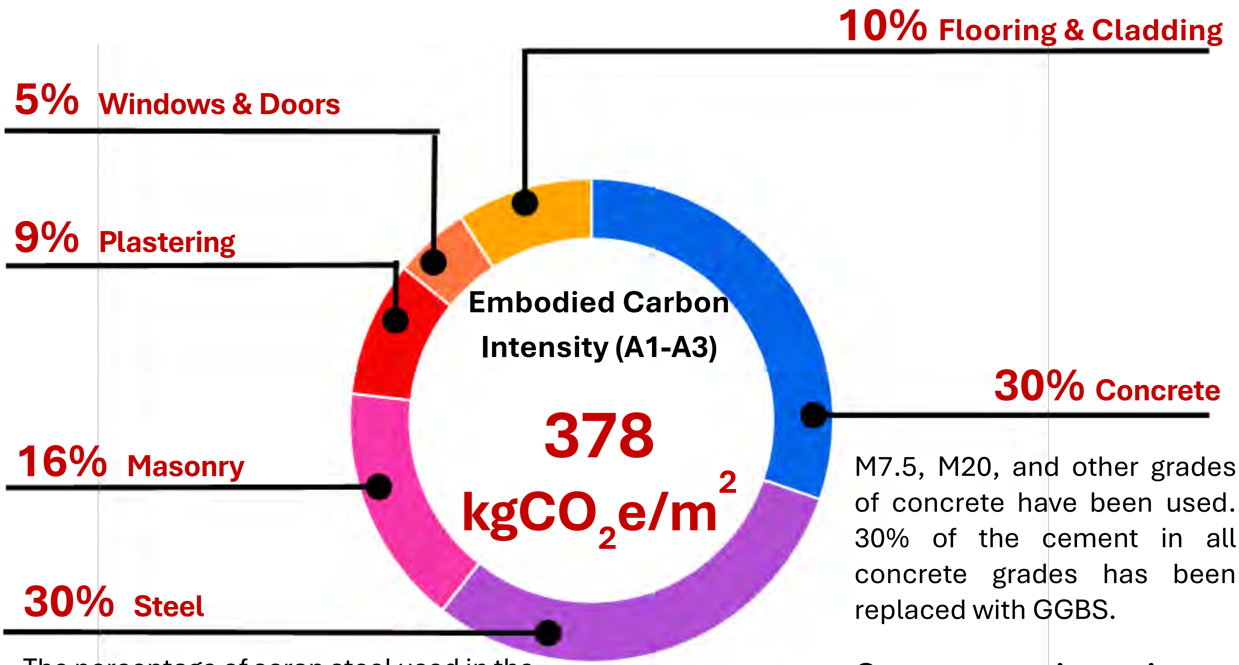
Building code: Z2-L-RF-O-2

Low-rise residential project with 253 villas. It consists of 2/3BHK, 2 storeys villas, a clubhouse, and no basement.

Building location	Bengaluru
Seismic zone	Zone 2
Height	Low-rise
Structural system	Reinforced framed structure
Parking	Open
Foundation type	Isolated column footings
Number of basements	0
Number of floors above ground	G+1
Built-up area (BUA) (m2)	85700.37



PRODUCT WISE EMISSIONS



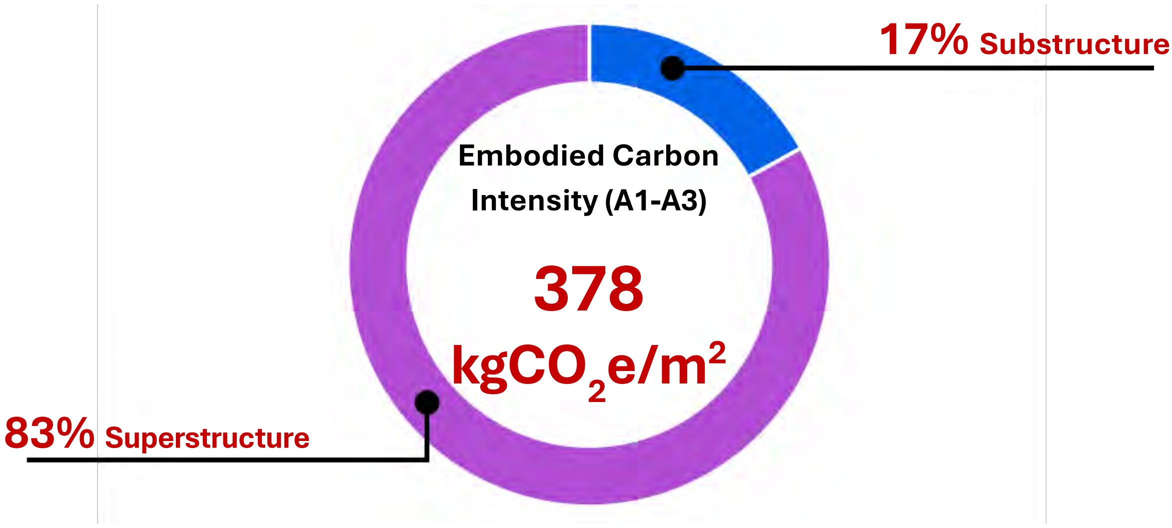
M7.5, M20, and other grades of concrete have been used. 30% of the cement in all concrete grades has been replaced with GGBS.

Concrete use intensity: 0.44 m^3/m^2 BUA

The percentage of scrap steel used in the reinforcement steel is not known. Hence, the average scrap percentage of 40% taken.

Steel use intensity: 40.54 kg/m^2 BUA

COMPONENT WISE EMISSIONS SHARE



Greentech Knowledge Solutions Pvt. Ltd.
197, Indraprastha Apartment,
Pocket 3, Sector 12, Dwarka,
New Delhi- 110078

Website: www.gkspl.in