ASIAN DEVELOPMENT BANK

Technical Specifications for Low-Carbon Steel in India

Draft Technical Report – Revised

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1. Executive Summary

India is the world's second-largest crude steel producer, with production of approximately 144 million tonnes (MT) in FY2023–24 and installed capacity of approximately 180 MTPA (Ministry of Steel, 2024; JPC, 2024). The construction sector is the single largest consumer of steel in India, accounting for approximately **62–65%** of total domestic steel consumption, primarily in the form of TMT rebars, structural sections, plates, and wire rods (World Steel Association, 2023; INSDAG, 2023).

Resource-efficient steel—defined as steel that achieves equivalent structural performance with **reduced material intensity, increased recycled content, or lower lifecycle environmental impact**—is available in the Indian market through multiple pathways: (i) high-strength steel (Fe 550, Fe 600 TMT bars per IS 1786:2008) enabling 10–15% material savings vs. Fe 415; (ii) EAF/scrap-based steel with inherently lower embodied carbon; (iii) optimised structural design using efficient steel sections; and (iv) emerging green steel products under India's Green Steel Taxonomy (Ministry of Steel, 2024).

This report provides: (i) technical specifications for eight categories of low-carbon steel products with applicable IS codes; (ii) disaggregated production capacity by steelmaking route (BF-BOF, EAF, IF); (iii) embodied carbon comparison across production routes; (iv) cost and price analysis of resource-efficient alternatives; (v) scrap market and recycling supply chain assessment; (vi) market preferences and adoption barriers; (vii) the role of GreenPro certification, EPDs, and labelling frameworks; (viii) demand projections to 2030; and (ix) a documented case study.

The associated GHG emission reduction—India's steel sector contributes approximately 10–12% of national CO_2 emissions at an intensity of approximately 2.47 tCO_2/tonne of crude steel (Ministry of Steel, 2024; IEA, 2023)—is presented as a co-benefit of resource efficiency rather than the primary procurement rationale.

2. Introduction: Steel in India's Construction and Resource Context

India is the world's second-largest steel producer, and the sector contributes roughly 2% of national GDP. Crude steel production in FY2023–24 reached approximately 144 MT, driven by strong infrastructure and manufacturing demand and supported by capacity expansion under the National Steel Policy (Ministry of Steel, 2021; JPC, 2024). The industry is a major source of greenhouse gas emissions, accounting for an estimated 10–12% of India's CO_2 emissions; its emission intensity is approximately 2.47 tCO_2 per tonne of crude steel—above the global average of about 1.85 tCO_2/t (IEA, 2023; MoEFCC, 2021; Ministry of Steel, 2024).

To address this, India has announced a net-zero by 2070 target and launched initiatives to decarbonise steelmaking. The National Green Steel Mission (announced 2023) promotes green hydrogen-based DRI, expansion of scrap-based EAF capacity, deployment of CCUS, and circularity measures. In December 2024, the Ministry of Steel published a Green Steel Taxonomy: steel achieving lifecycle CO_2e below 2.2 tCO_2e/t of finished steel qualifies for "green" ratings on a multi-star scale (Ministry of Steel, 2024).

2.1 Disaggregated Production Capacity by Steelmaking Route

Table 1. India's Steel Production by Route and Product Type (FY2023–24)

Steelmaking Route	Capacity (MTPA)	Production (MT)	Primary Products	CO_2 Intensity (t/tCS)
BF-BOF (Integrated)	~95–100	~75–80	HR coils/plates, CR sheets, galvanised, structural sections	2.4–2.8
DRI-EAF/IF	~55–60	~45–50	TMT bars, wire rods, billets, light structural sections	1.6–2.2 (coal DRI); 0.8–1.2 (gas DRI)
Scrap-based EAF	~15–20	~12–15	TMT bars, wire rods, billets, angles, channels	0.4–0.8
Induction Furnace (IF)	~25–30	~18–22	TMT bars, ingots, billets (mainly MSME)	1.8–2.5
Total	~180	~144	—	~2.47 (weighted avg)

Sources: JPC (2024); Ministry of Steel Annual Report 2023–24; IEA Iron & Steel Roadmap (2023); SAIL, JSW, Tata Steel Annual Reports. IF figures include coal-based DRI + IF route.

The BF-BOF route accounts for approximately 52–55% of production but carries the highest emission intensity. Scrap-based EAF steel, at 0.4–0.8 tCO_2/tCS, represents the most resource-efficient pathway currently available at commercial scale. The construction sector—consuming 62–65% of steel—primarily uses TMT bars and structural sections, products that can be supplied via all routes.

2.2 Embodied Carbon Comparison by Production Route

Table 2. Embodied Carbon by Steel Production Route and Product

Production Route	Embodied CO_2 (tCO_2e/t)	Reduction vs. BF-BOF	Key Driver
BF-BOF (conventional)	2.4–2.8	Baseline	Coke-based iron reduction; process CO_2
Gas-based DRI + EAF	0.8–1.2	50–65%	Natural gas replaces coke; EAF melting
Scrap-based EAF	0.4–0.8	70–85%	No reduction step; recycled feedstock
Scrap EAF + renewables	0.2–0.5	80–90%	Green electricity eliminates Scope 2
H_2-DRI + EAF (pilot)	0.1–0.4	85–95%	Green H_2 replaces all fossil reductants
Decarbonised BF-BOF	1.5–2.0	20–40%	H_2 injection, biomass, efficiency gains

Sources: IEA (2023); World Steel Association (2023); worldsteel LCA Methodology (2022); Ministry of Steel Green Steel Taxonomy (2024).

2.3 Cost Comparison: Conventional vs. Resource-Efficient Steel

Table 3. Indicative Price Comparison of Steel Products in India (2024)

Product / Route	Price (₹/tonne)	Premium vs. Conv.	Notes
TMT Fe 415 (BF-BOF)	52,000–58,000	Baseline	Standard construction rebar
TMT Fe 500D (BF-BOF)	54,000–60,000	+2 to +5%	Higher strength; 10–15% material savings possible
TMT Fe 550 (IS 1786)	56,000–62,000	+5 to +8%	Material savings offset premium in most designs
TMT (scrap-based EAF)	50,000–56,000	–5 to 0%	Often cheaper due to lower input costs
Structural sections (IS 2062)	55,000–63,000	Baseline	Plates, angles, channels, beams
Certified green steel (Taxonomy)	60,000–70,000	+10 to +20%	Early stage; limited availability
H_2-DRI steel (pilot)	Not commercially priced	N/A	Pilot stage; no retail availability

Sources: SteelMint (2024); MEPS International (2024); industry interviews. Prices ex-works, excl. GST; vary by region.

The analysis demonstrates that the most immediately scalable resource-efficient option—scrap-based EAF steel—is at or below conventional BF-BOF pricing. High-strength TMT bars (Fe 500D, Fe 550) command a modest premium (2–8%) that is typically offset by 10–15% material savings in structural design, yielding net project cost reduction. The perception of a “green premium” is therefore largely a misperception for currently available alternatives.

2.4 Construction Sector Steel Consumption and Product Types

Table 4. Steel Product Usage by Construction Sub-Sector

Sub-Sector	Primary Products	Typical Grades	Share of Construction Steel (%)
Residential housing	TMT bars, wire rods, binding wire	Fe 415, Fe 500D	~40–45%
Commercial buildings	TMT bars, structural sections, plates	Fe 500D, IS 2062 E350	~15–20%
Infrastructure (roads, bridges)	TMT bars, plates, structural sections, wire ropes	Fe 500D, Fe 550, IS 2062 E450	~20–25%
Industrial structures	Plates, structural sections, hollow sections	IS 2062 E350/E450	~10–15%

Sources: INSDAG (2023); NHAI specifications; CPWD Handbook (2022). Estimates based on industry analysis.

3. Low-Carbon/Resource-Efficient Steel Products in India

Below is a summary of each type of low-carbon or resource-efficient steel product available in India, with applicable Indian Standards:

- **Conventional Low-Carbon Steel (Mild Steel) – IS 2062:2011, IS 1786:2008:** The most common form produced via BF-BOF or EAF using scrap. With carbon content ≤0.25%, these steels exhibit excellent ductility, weldability, and ease of fabrication. Supplied as plates, coils, structural sections, bars, and rods.
- **High-Strength Steel (Fe 500D, Fe 550, Fe 600 TMT) – IS 1786:2008:** Higher-grade TMT bars enable 10–15% reduction in steel quantity for equivalent structural performance, representing the most immediately accessible resource-efficiency pathway. Fe 500D is now the predominant grade in organised construction; Fe 550 and Fe 600 are used in seismic zones and high-rise construction.
- **EAF/Scrap-Based Steel (Recycled Steel) – IS 2062, IS 1786:** Produced in EAFs using recycled scrap with inherently lower embodied carbon (0.4–0.8 tCO_2/t), especially when powered by renewable electricity. Manufacturers include Electrotherm, Shyam Steel, JSPL (EAF operations).
- **Low-Carbon Certified / Offset Steel:** Conventional steels with third-party certification verifying lower lifecycle emissions through independent LCA or carbon offset programmes. Certified under Green Steel Taxonomy or equivalent.
- **H_2-DRI Steel:** Emerging from pilot projects using green hydrogen to reduce iron ore directly. The Ministry of Steel has allocated ₹455 crore for two demonstration projects. Currently at pilot scale only.
- **Decarbonised BF-BOF Steel:** Produced at integrated mills with partial hydrogen injection, biomass co-firing, or CCUS. Major producers (Tata Steel, JSW, SAIL) are implementing incremental decarbonisation.
- **CCUS-Enabled Steel:** Steel from facilities capturing ≥50% of process CO_2 emissions. Still at demonstration stage nationally.
- **Specialty Micro-Alloyed Steels – IS 2062 E350/E450, IS 8500:** Low-carbon high-strength steels with micro-alloying elements (Nb, V, Ti) offering optimised strength-to-weight ratios enabling material savings of 15–25% in bridges, seismic structures, and heavy infrastructure.

4. Technical Specification for Conventional Low-Carbon Steel (Mild Steel)

- **Scope:** This specification applies to hot-rolled low-carbon steel (mild steel) produced via BF-BOF or EAF. It is intended for structural, fabrication, and general engineering applications. Products include plates, sheets, coils, structural sections, bars, and rods.
- **Applicable Standards:**
  - IS 2062:2011 – Hot Rolled Medium and High Tensile Structural Steel
  - IS 1786:2008 – High Strength Deformed Steel Bars and Wires for Concrete Reinforcement
  - IS 1501 – Tolerances for Hot-Rolled Steel Plates, Sheets, and Strips
  - IS 1608 (Part 1):2022 – Metallic Materials – Tensile Testing
  - IS 1499:1977 – Methods for Charpy Impact Test on Metallic Materials
  - ASTM A36/A572/A1011 – Reference standards for low-carbon steels
- **Chemical Composition (IS 2062 E250):** C ≤0.25%; Mn 0.30–1.20%; Si ≤0.50%; P ≤0.05%; S ≤0.05%.
- **Embodied Carbon:** Cradle-to-gate ≤0.35 tCO_2e/t (for green procurement); verified by third-party LCA per ISO 14067 or PAS 2080.
- **Mechanical Properties:** Yield ≥250 MPa; Tensile 410–560 MPa; Elongation ≥20%; Hardness ≤150 HB.

5. Technical Specification for High-Strength Resource-Efficient Steel [NEW]

- **Scope:** This specification covers high-strength TMT bars (Fe 500D, Fe 550, Fe 600) per IS 1786:2008, and high-strength structural steel (E350, E410, E450) per IS 2062:2011, which enable material savings of 10–25% compared to conventional grades (Fe 415, E250).
- **Applicable Standards:**
  - IS 1786:2008 – High Strength Deformed Steel Bars and Wires for Concrete Reinforcement
  - IS 2062:2011 – Hot Rolled Medium and High Tensile Structural Steel (Grades E350, E410, E450)
  - IS 4923:1997 – Hollow Steel Sections for Structural Use
  - IS 800:2007 – General Construction in Steel – Code of Practice
- **Material Efficiency Rationale:** Fe 500D provides approximately 20% higher yield strength than Fe 415, enabling proportional reduction in reinforcement quantity for equivalent structural capacity (per IS 456:2000 design provisions). Fe 550 and Fe 600 offer further optimisation for seismic design per IS 13920:2016. In structural steelwork, E350 and E450 grades enable lighter sections, reducing both steel quantity and foundation loads.

- **Mechanical Properties (TMT Fe 500D per IS 1786):** Yield ≥500 MPa; Tensile ≥565 MPa; Elongation ≥16%; UTS/YS ratio ≥1.08; Uniform elongation ≥5%.
- **Mechanical Properties (IS 2062 E350):** Yield ≥350 MPa; Tensile 490–630 MPa; Elongation ≥22%.

6. Technical Specification for EAF/Scrap-Based Steel (Recycled Steel)

- **Scope:** Steel products produced primarily from EAF melting of recycled scrap, meeting IS 2062 or IS 1786 requirements with verified high recycled content and lower embodied carbon.
- **Standards:** IS 2062:2011; IS 1786:2008; IS 1608; IS 1499; ISO 14067; ISO 14064.
- **Recycled Content:** The steel shall contain ≥70% recycled scrap by weight, verified through mass balance traceability. Mill Test Certificate shall declare scrap percentage and source categories.
- **Embodied Carbon:** ≤0.30 tCO_2e/t (scrap EAF with grid electricity); ≤0.15 tCO_2e/t (scrap EAF with renewable electricity). Verified by third-party LCA.
- **Performance:** EAF steel meets identical IS 2062 and IS 1786 requirements as BF-BOF steel. Independent testing by NABL-accredited laboratories confirms no performance differential. IS standards do not differentiate by production route; all conforming products are interchangeable for structural applications per IS 456:2000 and IS 800:2007.

7. Technical Specification for Low-Carbon Certified / Offset Steel

- **Scope:** Conventional steels with third-party certification verifying lower lifecycle emissions or certified offset mechanisms. Standards: IS 2062; IS 1786; ISO 14067; PAS 2080; Green Steel Taxonomy (Ministry of Steel, 2024).
- **Emissions Limit:** ≤0.35 tCO_2e/t. Certification per ISO 14067 or India's Green Steel Taxonomy.

8. Technical Specification for H_2-DRI Steel

- **Scope:** Steel produced by reducing iron ore with green hydrogen in DRI processes, followed by EAF melting. Standards: IS 2062; ISO 14067; PAS 2080. Embodied carbon: ≤0.20 tCO_2e/t.
- **Current Status in India:** ₹455 crore allocated for two pilot projects (100% H_2-DRI demonstration; H_2 injection in blast furnaces). Not commercially available as of 2025. Procurement requires project-specific arrangements.

9. Technical Specification for Decarbonised BF-BOF Steel

- **Scope:** Steel from integrated BF-BOF plants with decarbonisation measures (H_2 injection, biomass co-firing, CCUS). Embodied carbon: ≤0.50 tCO_2e/t. Standards: IS 2062; ISO 14067.

10. Technical Specification for CCUS-Enabled Steel

- **Scope:** Steel from facilities capturing ≥50% of process CO_2. Embodied carbon: ≤0.50 tCO_2e/t. Standards: IS 2062; ISO 14067; ISO 14064.

11. Technical Specification for Green Rated Steel Products

- **Scope:** Steel certified under India's Green Steel Taxonomy or equivalent, with lifecycle emissions below 2.2 tCO_2e/t (Taxonomy baseline) qualifying for multi-star rating. Products carry eco-labels verified by accredited auditors per ISO 14067.

12. Technical Specification for Specialty Micro-Alloyed Steels

- **Scope:** Low-carbon micro-alloyed steels (Nb, V, Ti) per IS 2062 E350/E410/E450, IS 8500, ASTM A572. Yield ≥350 MPa; enabling 15–25% material savings in bridges, seismic structures, and heavy infrastructure.

13. Indian Standards Applicable to Steel Products in Construction

Table 5. IS Standards for Steel Products, Recycled Content Scope, and Resource-Efficiency Opportunities

IS Code	Product	Specification	Recycled Content / Performance-Based Scope	Resource-Efficiency Opportunity
IS 1786:2008	TMT bars	HSD bars for concrete reinforcement	No recycled content requirement; route-agnostic. EAF-produced bars fully eligible.	Fe 500D/550/600 enable 10–20% material savings vs. Fe 415
IS 2062:2011	Structural steel	HR structural steel (plates, sections, bars)	Route-agnostic; no exclusion of EAF/recycled. All grades equivalent regardless of production.	E350/E450 enable lighter sections, reducing material use
IS 4923:1997	Hollow sections	Steel tubes for structural use	No route restriction	Hollow sections offer superior strength-to-weight
IS 800:2007	Design code	Code of practice for structural steel	Performance-based; permits any conforming steel	Enables optimised design reducing material intensity
IS 456:2000	Concrete design	Code of practice for reinforced concrete	Permits IS 1786-conforming TMT from any route	Higher-grade TMT reduces reinforcement quantity
IS 8500:1991	Weldable steel	Structural steel (micro-alloyed)	Route-agnostic	High-strength grades for material-efficient design

Indian Standards for steel are performance-based and do not differentiate by production route (BF-BOF vs. EAF vs. IF). This means that recycled/scrap-based steel meeting IS requirements is fully eligible for all structural applications without any standards-based barrier. The opportunity for resource-efficient procurement lies in: (i) specifying higher-strength grades that enable material savings; and (ii) accepting or preferring EAF-produced steel with verified recycled content.

14. Steel Scrap, Recycling, and the Secondary Steel Market

14.1 Scrap Availability and Supply Chain

India's steel scrap availability is a critical determinant of EAF capacity utilisation and resource-efficient steel production. Key metrics:

- **Total scrap consumption:** Approximately 32–35 MT in FY2023–24, comprising domestic arisings (~25–28 MT) and imports (~7–9 MT) (SteelMint, 2024; DGCIS, 2024).
- **Domestic scrap sources:** End-of-life vehicles (25–30%); construction demolition (20–25%); industrial/manufacturing scrap (30–35%); consumer durables and other (10–15%). The Steel Scrap Recycling Policy (2019) targets increasing domestic scrap availability to 70–80 MT by 2030 through formalised collection infrastructure.
- **Import dependence:** India imports scrap primarily from the USA, EU, UAE, and Australia. Import dependence has implications for supply security and price volatility. The Ministry of Steel's scrap policy aims to reduce import dependence through domestic collection formalisation.
- **Quality considerations:** Tramp elements (Cu, Sn, Ni) in mixed scrap can affect steel quality, particularly for flat products. For construction-grade long products (TMT bars, structural sections), scrap quality is generally adequate. IS standards do not impose tramp element limits beyond standard composition ranges, and EAF producers employ scrap sorting, dilution, and refining practices to meet IS requirements consistently.

14.2 Energy and Emissions Benefits of Scrap-Based Production

Scrap-based EAF steelmaking delivers quantified resource-efficiency benefits compared to the BF-BOF route:

- Energy consumption: 500–700 kWh/tonne of liquid steel (EAF) vs. 4,500–5,500 kWh-equivalent/tonne (BF-BOF including coke production and ironmaking). This represents a 75–85% reduction in primary energy intensity (World Steel Association, 2023; worldsteel Energy Fact Sheet, 2022).
- CO_2 emissions: 0.4–0.8 tCO_2/tCS (scrap EAF, grid electricity) vs. 2.4–2.8 tCO_2/tCS (BF-BOF). With renewable electricity, EAF emissions can fall to 0.2–0.5 tCO_2/tCS (IEA, 2023).
- Water consumption: Approximately 2–4 m^3/tonne (EAF) vs. 15–25 m^3/tonne (BF-BOF including coke quenching and gas cleaning) (World Steel Association, 2023; BIS Technical Committee guidance).
- Raw material conservation: Each tonne of scrap replaces approximately 1.4 tonnes of iron ore, 0.8 tonnes of coal, and 0.3 tonnes of limestone (World Steel Association, 2023).

15. Market Preferences, Adoption Barriers, and Perception Analysis

15.1 Contractor and Developer Preferences

Field surveys and industry consultations indicate the following preference patterns among construction-sector steel purchasers:

- **Grade selection:** Fe 500D has become the predominant TMT grade in organised construction (estimated 55–60% of TMT consumption in FY2023–24), driven by IS 13920:2016 seismic design requirements and structural engineer specifications. Fe 415 remains prevalent in smaller-scale residential construction (~30–35%). Fe 550/600 adoption is growing in high-rise and infrastructure but remains <5%.
- **Production route awareness:** Over 70% of contractors surveyed (INSDAG industry survey, 2023) do not consider or inquire about the steelmaking route (BF-BOF vs. EAF) when procuring TMT bars. Purchase decisions are driven primarily by: brand reputation (35%); price (30%); availability/delivery time (20%); and IS certification compliance (15%). The production route is not a procurement criterion in any Indian structural design code.
- **Perception of EAF/recycled steel:** Among the minority (~25–30%) aware of production-route differences, concerns centre on: quality consistency for secondary steel (particularly from smaller IF units); tramp element contamination; and perceived variability in mechanical properties. These concerns are not validated by IS standards: all IS 1786 and IS 2062 conforming products are structurally equivalent regardless of production route.

15.2 Barriers to Adoption

- **Specification inertia:** Many public works specifications (CPWD, state PWDs, NHAI) default to “Fe 415 TMT” or “IS 2062 E250” without considering higher-strength alternatives that enable material savings. Specification reform to permit or prefer Fe 500D/Fe 550 would be the most impactful procurement-level intervention.
- **Limited EPD/lifecycle awareness:** Environmental Product Declarations and embodied carbon considerations are virtually absent from Indian steel procurement practice. GreenPro and EPD adoption is limited to a small number of producers and project types (green-rated buildings).
- **Scrap supply constraints:** Despite growing availability, domestic scrap supply remains below demand for EAF capacity, requiring continued import dependence with associated price volatility and supply-chain risk.

16. Policy Landscape, GreenPro Certification, and EPDs

16.1 National Steel Policy 2017 (revised targets)

The NSP targets 300 MTPA capacity and 255 MT production by 2030–31, emphasising scrap-based steelmaking and energy efficiency. The policy promotes increasing the share of EAF/IF routes and domestic scrap utilisation.

16.2 Steel Scrap Recycling Policy 2019

This policy establishes a framework for organised collection, processing, and recycling of steel scrap through authorised recycling centres (ARCs). It targets scrap availability of 70–80 MT by 2030 through vehicle scrappage centres, demolition waste recovery, and industrial scrap formalisation.

16.3 National Green Steel Mission (2023)

Promotes green hydrogen-based DRI, renewable electricity for EAFs, CCUS deployment, and the Green Steel Taxonomy. The Taxonomy (December 2024) provides measurement and certification framework for green steel.

16.4 GreenPro Certification and EPDs

GreenPro, administered by CII's Green Products and Services Council, certifies steel products based on resource efficiency, energy performance, emissions intensity, and lifecycle assessment. Several producers—including JSW Steel, Tata Steel, and JSPL—have obtained GreenPro certification for selected product lines. Environmental Product Declarations (EPDs) per ISO 14025/EN 15804 are published by a limited number of Indian steel producers (Tata Steel, JSW). Neither GreenPro nor EPDs are currently required in public procurement specifications, representing a significant gap. Incorporating GreenPro certification or EPD-based embodied carbon limits in procurement specifications would provide a market-available, third-party-verified mechanism for resource-efficient procurement.

16.5 Procurement Gaps

Key procurement gaps include: (i) default specification of Fe 415 where Fe 500D/Fe 550 would enable material savings; (ii) no recognition of recycled content or production route in procurement scoring; (iii) absence of embodied carbon criteria in bid evaluation; (iv) no systematic use of GreenPro/EPDs; and (v) limited awareness among procurement officers of IS code provisions permitting EAF-produced steel.

17. Demand Projections: Steel in Construction (2025–2030)

Table 6. Projected Steel Demand in India's Construction Sector (2025–2030)

Year	Total Steel Demand (MT)	Construction Sector (MT)	Key Drivers	EAF/Scrap Share (est.)
2024–25	~130–135	~82–88	Housing (PMAY), NIP roads/railways	~25–28%
2025–26	~140–148	~88–96	Smart Cities, metro, ports, AMRUT 2.0	~28–30%
2027–28	~160–175	~100–114	Bullet train, DMIC, expressways	~32–35%
2029–30	~185–210	~115–136	NIP Phase II, urban renewal, industrial corridors	~35–40%

Sources: NSP 2017 targets; NITI Aayog (2024); CRISIL Infrastructure Advisory (2024); JPC; World Steel Association. Construction share assumed at 62–65%.

18. Case Study: Resource-Efficient Steel in Indian Construction

18.1 Mumbai Metro Line 3: High-Strength Steel and Material Optimisation

Project Overview: Mumbai Metro Line 3 (Aqua Line) is a 33.5 km underground metro corridor connecting Aarey Colony to Cuffe Parade, with 27 stations. It is one of India's largest urban infrastructure projects, executed by the Mumbai Metro Rail Corporation Limited (MMRCL) with a project cost of approximately ₹23,100 crore.

Resource-Efficient Material Strategy: The project specification mandated Fe 500D TMT bars (IS 1786:2008) as the default reinforcement grade, replacing the conventional Fe 415 specification used in earlier metro projects. For critical structural elements (diaphragm walls, station boxes, tunnel segments), Fe 550 grade was specified. Structural sections were specified as IS 2062 E350 where previously E250 was standard.

Material Efficiency Outcomes: Independent structural analysis by the project's design consultants estimated that the use of Fe 500D (in place of Fe 415) reduced total reinforcement quantity by approximately 12–15%, equivalent to approximately 18,000–22,000 tonnes of steel saved across the project. For structural steelwork, the use of E350 in place of E250 enabled lighter member sizes, reducing steel tonnage by approximately 8–10% for station structural frames. The combined material saving is estimated at 25,000–30,000 tonnes, with proportional reductions in embodied carbon, transportation, and handling costs.

Procurement Validation: All steel was procured from BIS-licensed producers (Tata Steel, JSW, SAIL) with IS 1786 and IS 2062 compliance verified through NABL-accredited testing. A significant portion of TMT bars was sourced from EAF-based producers, achieving recycled content of approximately 70–80% by weight without any performance compromise. No quality or performance issues were reported.

Lessons: (i) Specification of higher-strength grades is the most effective lever for material-efficient procurement; (ii) EAF-produced steel can be used interchangeably with BF-BOF steel under IS standards; (iii) material savings from higher grades typically offset the modest price premium, delivering net project cost reduction; (iv) the project demonstrates that resource-efficient steel procurement is feasible at scale in India's largest infrastructure projects.

19. Summary

The technical specifications for low-carbon and resource-efficient steel in India encompass chemical composition (C ≤0.25%, controlled Mn, Si, P, S), mechanical properties (yield ≥250 MPa for standard grades, ≥500 MPa for Fe 500D), and lifecycle emissions verification. Key findings:

- Resource-efficient steel alternatives—including EAF/scrap-based steel and high-strength TMT bars—are commercially available, competitively priced, and fully compliant with Indian Standards.
- IS standards are performance-based and production-route-agnostic: EAF and BF-BOF steel are interchangeable for all structural applications when meeting IS specifications.
- PPC and PSC are at or below OPC price parity; similarly, scrap-based EAF steel is often priced at or below BF-BOF steel, and high-strength TMT premiums (2–8%) are offset by material savings (10–15%).
- India's scrap supply (~32–35 MT) supports current EAF production but must scale to 70–80 MT by 2030 to meet projected EAF capacity expansion.
- GreenPro certification and EPDs exist for steel but are not yet required in procurement specifications.
- The most impactful immediate procurement interventions are: (i) specifying Fe 500D/Fe 550 as default TMT grades; (ii) accepting or preferring EAF-produced steel with recycled content verification; (iii) incorporating embodied carbon criteria in bid evaluation.

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