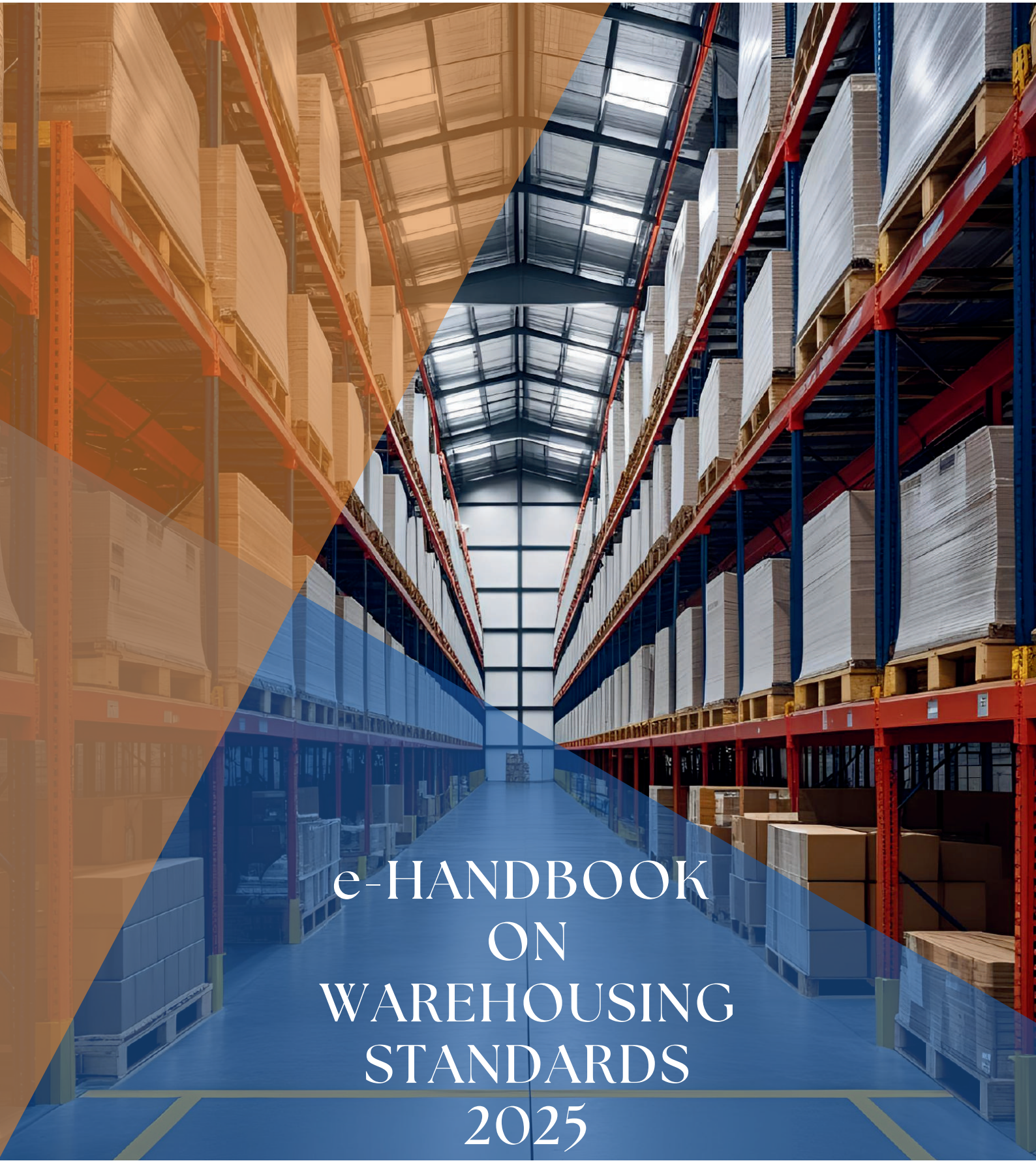
DEPARTMENT FOR PROMOTION OF INDUSTRY AND INTERNAL TRADE
MINISTRY OF COMMERCE & INDUSTRY,
GOVERNMENT OF INDIA

सत्यमेव जयते

PM GatiShakti
National Master Plan for Multi-Modal Connectivity



e-HANDBOOK ON WAREHOUSING STANDARDS 2025

WAREHOUSING ASSOCIATION OF INDIA

INDIA LOGISTICS

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सत्यमेव जयते

भारत सरकार
वाणिज्य एवं उद्योग मंत्रालय
उद्योग संवर्धन और आंतरिक व्यापार विभाग
GOVERNMENT OF INDIA
MINISTRY OF COMMERCE & INDUSTRY
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AND INTERNAL TRADE

FOREWORD

The modernisation of warehousing infrastructure is central to India's vision of developing a globally competitive logistics ecosystem. As supply chains evolve to become more integrated, data-driven, and customer-focused, the demand for robust, standardised, and future-ready warehousing solutions is being felt across every sector of the economy.

It is in this context DPIIT is introducing the 2025 edition of the *e-Handbook on Warehousing Standards*. This updated edition is the result of close collaboration among government institutions, industry stakeholders, technical bodies, and subject matter experts. It embodies our shared commitment to building logistics infrastructure that meets global benchmarks, while being rooted in the Indian context.

Since the release of the previous edition, we have witnessed substantial momentum in the implementation of the National Logistics Policy and the operationalisation of the PM GatiShakti framework. DPIIT along with Warehousing Association of India (WAI) has worked in close coordination with Central Ministries, State Governments, and private players to ensure coherent and efficient execution. The warehousing sector - both as a standalone industry and as a key enabler for manufacturing, retail, and e-commerce - has been at the heart of these efforts.

This handbook offers updated technical guidance on critical aspects such as warehouse design, palletization, racking systems, safety protocols, and automation. It also introduces new policy focus areas, showcases practical case studies, and outlines sustainability standards to support effective implementation on the ground. The document is intended to be accessible and actionable for a wide array of stakeholders - from state-level planning bodies and regulators to infrastructure developers and logistics service providers.

I am confident that this revised edition will serve as a practical reference and planning tool, contributing meaningfully to our collective goal of reducing logistics costs, enhancing service quality, and building world-class logistics infrastructure across the country.

23/06/2025

(Amardeep S. Bhatia)
23.06.2025

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ACKNOWLEDGEMENTS

The e-Handbook on Warehousing Standards (2025 Edition) is the product of a collaborative initiative led by the Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry, Government of India, in partnership with the Warehousing Association of India (WAI). This publication has been enriched by the valuable insights and contributions of logistics professionals, policymakers, industry associations, and a broad range of stakeholders across the warehousing ecosystem.

We extend our sincere gratitude to Shri Amardeep Singh Bhatia, Secretary, DPIIT, for his insightful observations during the consultative process. His strategic guidance played a pivotal role in ensuring the alignment of this handbook with India's overarching vision for logistics modernization and infrastructure development.

We are especially thankful to Shri Pankaj Kumar, Joint Secretary, DPIIT; Shri E. Srinivas, Former Joint Secretary, DPIIT; and Dr. Jivisha Joshi Gangopadhyay, Deputy Secretary, DPIIT, for their leadership, active engagement, and consistent feedback throughout the preparation of this handbook. Dr. Gangopadhyay's unwavering focus on standardization and sectoral development has been a cornerstone of this effort.

We also acknowledge the dedicated contributions of Ms. Richa Sekhani, Ms. Harshita Sharma, and Mr. Kapil Chaudhary, consultant Asian Development Bank (ADB). Their efforts have been instrumental in aligning the handbook with key national frameworks such as the National Logistics Policy and the PM GatiShakti initiative.

We are grateful to the below team at the Warehousing Association of India (WAI) for their technical expertise, industry knowledge, and practical guidance. Their contributions—particularly in formulating standards, developing case studies, and drafting operational frameworks—have been integral to the success of this publication.

Mr. Manu Raj Bhalla, President; Mr. Arif Siddiqui, Vice President; Mr. Suni Tyagi, Honorary Secretary; Mr. Seshadri Kulkarni, Executive Director; Mr. S.A. Mohan, Chair of Technical Committee; Mr. Vasu Ramanujam, Chair of Marketing; Mr. Mohit Kapoor, Chair of Projects and Events; Mr. Unni Krishnan, Mr. Parmeet Bhalla, Mr. Ashok Gupta, Mr. Abhishek Chaturvedi, and Mr. Parag Warerkar – Technical Committee Task Force.

We also wish to recognize the valuable inputs received from a wide range of industry bodies, including BIS, CII, ASSOCHAM, FICCI, and PHDCCI, as well as logistics professionals, infrastructure service providers, and state government representatives. Their diverse perspectives have ensured that this handbook is both comprehensive and forward-looking.

Finally, we express our heartfelt thanks to all contributors who generously shared their time, expertise, and feedback. We hope this handbook serves as a valuable resource in strengthening and advancing India's warehousing ecosystem.

WAREHOUSING ASSOCIATION OF INDIA

ABOUT THE PUBLISHER

The **Warehousing Association of India (WAI)** was established as a Section 8 Company on **8th November 2021**, with a mission to promote and advance the interests of the warehousing industry in India. WAI's members and key stakeholders include:

- **Warehouse and Logistics Park Developers**
- **Warehouse Users** such as retail, manufacturing, and e-commerce companies
- **Warehouse Operators**, including 3PL, logistics, and warehousing service providers
- **Associated Solution Providers**, such as equipment manufacturers, software companies, and warehouse design firms

VISION

To be the nodal body to facilitate the ease of establishing and operating world-class warehouses in India across the entire value chain of stakeholders namely developers, operators, and users of warehouses.

MISSION

- Promote and establish world-class sustainable warehouses in India
- Standardization of warehousing infrastructure and processes
- Facilitate the setting up of intelligent warehouses through automation to bring greater efficacy & productivity to warehouses
- Grading/ Rating of warehouses.
- Skilling warehousing workforce
- Collaborate closely with government and non-government stakeholders to create a conducive business environment for warehousing
- Promote greater investment in the warehousing Industry

Aligned with the vision of **PM GatiShakti – National Master Plan (NMP)**, WAI aims to simplify and support the establishment and operation of world-class warehousing infrastructure across India. We are honored that the **Department for Promotion of Industry and Internal Trade (DPIIT)** has entrusted WAI with the responsibility of updating and publishing this e-Handbook. We extend our sincere gratitude to:

- **Shri Amardeep S. Bhatia**, Secretary, DPIIT
- **Shri Pankaj Kumar**, Joint Secretary, Logistics Division, DPIIT
- **Shri E. Srinivas**, Former Joint Secretary, Logistics Division, DPIIT
- **Dr. Jivisha Joshi Gangopadhyay**, Deputy Secretary, Logistics Division, DPIIT

Their guidance and support have been instrumental in bringing this initiative to life.
This valuable e-Handbook is designed to benefit all stakeholders in the warehousing ecosystem, fostering standardization and contributing to the development of world-class warehousing infrastructure in the country.

WAI is committed to **updating this document periodically**, ensuring it reflects the latest trends, best practices, and technological advancements in the warehousing sector.

Manu Raj Bhalla
President,
Warehousing Association of India

ABOUT THE e-HANDBOOK

The e-Handbook on Warehousing Standards is a collaborative effort developed with input from industry experts, stakeholders, and regulatory bodies. It provides a comprehensive overview of national and international standards, best practices, and emerging technologies impacting the warehousing sector.

Recognizing the critical role of warehousing in India's logistics ecosystem, the Ministry of Commerce and Industry, through its Logistics Division, initiated this handbook to address the need for standardized warehousing practices. By consolidating existing standards and incorporating industry recommendations, the handbook aims to enhance efficiency, reduce costs, and facilitate global integration within the warehousing industry.

This e-Handbook draws on standards issued by the Bureau of Indian Standards (BIS) and the Warehousing Development and Regulatory Authority (WDRA) and incorporates recommended practices where standards are lacking. It serves as a valuable resource for industry professionals to align their operations with national and global benchmarks, ultimately contributing to the growth and competitiveness of the Indian warehousing sector.

SCOPE OF THE E-HANDBOOK

This e-Handbook provides a consolidated overview of warehousing standards issued by national and international standards organizations including the Bureau of Indian Standards (BIS) and the Warehousing Development and Regulatory Authority (WDRA). It also highlights gaps in the current standards landscape and offers recommendations based on widely accepted industry practices and international benchmarks.

The Handbook is primarily applicable to:

- General-purpose industrial and commercial warehouses
- Warehouses within integrated logistics parks and distribution centres
- Modern, high-specification warehouses that follow current industry norms for safety, infrastructure, and operational efficiency (commonly referred to in industry parlance as Grade A or B)
- E-commerce, FMCG, and retail fulfilment centres

The Handbook references selected standards relevant to other warehouse types, such as:

- Commodity and agri-warehouses governed by WDRA or BIS guidelines
- Temperature-controlled warehouses, where BIS standards for storage of specific perishable commodities are cited
- Underground storage tanks and open yards, where certain international standards (e.g., API, NLPA) are mentioned

However, it does not provide detailed design or operational guidance for these specialized warehouse types. Users developing such facilities should consult domain-specific technical codes and regulatory frameworks in addition to this Handbook.

In terms of the warehouse development lifecycle, this Handbook primarily supports the following phases:

- **Requirements analysis:** By outlining applicable standards and regulatory expectations
- Design and planning: Through chapters on infrastructure, layout, sustainability, racking, and material handling
- **Construction:** Through structural and equipment standards, fire safety, flooring, roofing, and other best practices
- **Operation and maintenance:** With guidance on warehouse management systems, security, occupational safety, illumination, and periodic audits
- **Modernization:** Through dedicated chapters on automation, artificial intelligence, and digital integration

The Handbook does not address the testing, commissioning, or retirement phases in detail. The 2025 edition introduces new chapters on:

- Policy Thrust Areas for enabling environment Warehousing
- Use Cases and Case Studies
- Warehouse Automation
- Artificial Intelligence and Smart Warehousing

Each chapter includes defined objectives and expected outcomes to support clarity and practical implementation. This Handbook is intended as a resource for:

- Warehouse Developers
- Operators and Occupiers
- Third-Party Logistics (3PL) Providers
- Policy Makers and Regulatory Authorities

By consolidating existing standards and best practices, the Handbook aims to support the adoption of consistent, efficient, and forward-looking approaches across India's warehousing sector.

TABLE OF CONTENTS

Chapter 08: Warehousing Technologies and Applications

This new chapter outlines how warehousing technology can streamline workflows, reduce errors, lower costs, improve safety, and enhance scalability. The chapter also highlights the benefits of automation (including AI), including increased throughput, improved service quality, optimized space utilization, faster ROI, and enhanced data analysis. It emphasizes the importance of automation in today's competitive market and provides an overview of the different components and solutions involved in warehouse automation.

Chapter 09: Policy Thrust Areas for Enabling Warehousing Ecosystem

This new chapter highlights the benefits and strategic focus of a policy designed to support the growth and modernization of the warehousing sector across India. Aligned with evolving technologies and emerging industry trends, the policy provides targeted strategies and actionable recommendations across key thrust areas to strengthen the overall warehousing ecosystem.

Chapter 10: Case Studies

This new chapter on case studies illustrate real-world applications of the standards and best practices outlined in the "Warehousing Standards Handbook." Each case study provides a detailed examination of specific challenges faced by companies in different industries, the solutions they implemented, and the outcomes achieved.

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AGV	Automated Guided Vehicle
AISC	American Institute of Steel Construction
AMR	Autonomous Mobile Robots
ANSI	American National Standards Institute
API	Application Programming Interface
APS	Advanced Planning and Scheduling
ARAI	Automotive Research Association of India
AS/RS	Automated Storage and Retrieval Systems
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
BIS	Bureau of Indian Standards
CME	Chicago Mercantile Exchange
CMVR	Central Motor Vehicles Rules
CWC	Central Warehousing Corporation
DC	Distribution Centre
DIN	Deutsches Institut für Normung
ECBC	Energy Conservation Building Codes
ERP	Enterprise Resource Planning
EN	European Standards
FCI	Food Corporation of India
FIFO	First In, First Out
GS1	Global Standards One (organization for global business communication standards)
ICE	Internal combustion engine
IEC	International Electrotechnical Commission
IGBC	Indian Green Building Council
IoT	Internet of Things
ISO	International Organization for Standardization

LIST OF ABBREVIATIONS

JIT	Just-In-Time
JIS	Japanese Industrial Standards
LBMA	London Bullion Market Association
LEED	Leadership in Energy and Environmental Design
LIFO	Last In, First Out
LME	London Metal Exchange
LTL	Less-than-Truckload
MBMA	Metal Building Manufacturers Association
MHE	Material Handling Equipment
NBC	National Building Code
NLPA	National Leak Prevention Association
NWPCA	National Wooden Pallet and Container Association
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
RFID	Radio Frequency Identification
RP	Recommended Practice
SEMA	Speed Equipment Manufacturing Association
SHGC	Solar Heat Gain Coefficient
SKU	Stock Keeping Unit
SOP	Standard Operating Procedures
SRI	Solar Reflective Index
STI	Steel Tank Institute
TAPA	Transport Asset Protection Association
TMS	Transportation Management System
VMI	Vendor-Managed Inventory
WAI	Warehousing Association of India
WMS	Warehouse Management System
WRDA	Warehousing Development and Regulatory Authority

EXECUTIVE SUMMARY

India's warehousing sector is booming, fueled by e-commerce growth, foreign investments, and demand for efficient logistics. The Goods and Services Tax (GST) has spurred consolidation of warehousing operations, while the surge in e-commerce and logistics in urban and semi-urban areas has driven the need for modern, large-scale warehouses. Government policies like the National Logistics Policy (NLP) aim to cut logistics costs, making warehousing a key component of India's supply chain evolution. Meanwhile, sustainability is gaining traction, with the sector facing pressure to adopt green practices such as energy-efficient designs, waste reduction, and sustainable materials. These efforts are crucial for minimizing environmental impact, aligning with India's sustainability objectives, and meeting global stakeholders' expectations for eco-conscious supply chains.

A major trend in the sector is the increasing preference for Grade A warehousing facilities that offer superior infrastructure, technological integration, and compliance with international standards. While "Grade A" and "Grade B" are useful nomenclature in commercial practice, they are not part of BIS or WDRA classification frameworks. No formal Indian standard defines these grades. The distinction is based on functional specifications, safety compliance, and infrastructure quality. Grade A warehouses typically have the following aspects and features:

- Pre-engineered building (PEB) structure with clear height of 10–12+ meters
- FM2 category flooring with high load-bearing capacity (5–10 tons/m^2)
- Dock levelers with dock-to-door ratio (e.g., 1:8000 sq. ft.)
- Fire safety (sprinklers, hydrants) as per NBC/Factory Act standards
- Wide column spacing (9–12 meters)
- Ample truck parking and turning radius
- Dedicated office/admin blocks
- Warehouse Management System (WMS) readiness
- Compliance with green building norms (LEED, IGBC – in some cases)

This shift has attracted substantial foreign investment, with leading global companies supporting the development of expansive logistics parks. However, the sector still faces significant challenges. Infrastructure remains a major hurdle, as many warehouses operate in outdated facilities with poor connectivity to key transport networks like ports, highways, and railways. The industry remains fragmented, with numerous small, unorganized players that struggle to maintain operational efficiency, leading to inconsistent service quality and logistical inefficiencies.

The total warehousing stock in the top 20 cities is roughly 533 million square feet. This expansion is driven by increasing demand from sectors such as e-commerce, third-party logistics (3PL), manufacturing, and the government's intense focus on improving logistics infrastructure. Approximately 204 million square feet of organized warehousing supply, Grade A Warehouse in industry parlance, exists in India as of H1 2024, surpassing the supply of 189 million square feet of Grade B, older facilities lacking some of the advanced features of Grade A. The balance 25% in area Grade C, which are mostly small and unorganized. Major industrial hubs like Delhi-NCR, Mumbai, Bengaluru, Chennai, and Pune account for a significant portion of Grade A warehouses, due to their strategic locations, infrastructure, and proximity to consumption centers. Tier II and III cities are witnessing a surge in Grade A warehouse development, contributing approximately 30% of the inventory in these regions. Cities like Lucknow, Coimbatore, and Nagpur are becoming new warehousing hubs due to improved infrastructure and rising local demand. (Source: JLL, 2024)

Technological adoption in the warehousing sector varies significantly across the industry.. While some facilities have embraced automation through systems like Automated Storage and Retrieval Systems (ASRS) and Warehouse Management Systems (WMS), many still rely on manual processes. This technological gap leads to reduced data visibility, increased labour costs, and greater potential for delays and inaccuracies in inventory management. The sector also faces labour-related challenges, such as a shortage of skilled workers, high turnover, and inadequate training. Many warehouses depend on temporary labour, which is often ill-equipped to operate modern equipment efficiently. Regulatory and compliance issues further complicate matters, with varying requirements across state and national levels creating operational disruptions and additional costs.

Standardization is critical for overcoming these challenges, enabling the warehousing industry to streamline operations, reduce handling times, minimize errors, and lower logistics costs. The National Logistics Policy (NLP) underscores standardization as a key strategy to reduce logistics costs to single-digit percentages of GDP, strengthening India's position in the global supply chain. Uniform practices also enhance safety and compliance, which are vital for managing high-value goods and meeting the stringent requirements of multinational corporations entering India. Adhering to robust safety standards—covering structural integrity, fire prevention, and material handling—ensures operational reliability. Moreover, standardization fosters transparency and accountability across the supply chain, enabling precise data collection and tracking, which is essential for industries like pharmaceuticals and e-commerce that demand accurate inventory management and rapid order fulfillment.

Sustainability is an increasingly pressing priority, and standardized practices can drive eco-friendly warehousing operations. By establishing benchmarks for energy efficiency, waste reduction, and sustainable material use, warehouses can significantly lower their environmental footprint while aligning with global sustainability standards. Promoting green building designs, energy-efficient systems, and renewable energy adoption not only supports India's broader environmental goals but also enhances corporate social responsibility, meeting the expectations of environmentally conscious stakeholders.

Standardization streamlines the integration of technology into warehousing operations by aligning practices with global benchmarks, facilitating the adoption of advanced solutions like IoT, RFID, and automated systems for real-time inventory tracking and predictive analytics. Digitalization enhances demand forecasting and dynamic inventory management, enabling warehouses to adapt swiftly to market changes and customer needs. As warehousing becomes increasingly technology-driven, these innovations deliver substantial competitive advantages, boosting efficiency and customer satisfaction.

Looking ahead, the adoption of advanced technologies is set to accelerate, with automation and artificial intelligence playing increasingly pivotal roles. Warehouses are being transformed into intelligent, data-driven hubs through the integration of automated systems and IoT-enabled solutions—enhancing productivity and minimizing errors. At the same time, multi-modal logistics parks, which integrate warehousing with road, rail, and in some cases, inland waterway connectivity, are gaining traction. These facilities align with the National Logistics Policy's (NLP) goals by streamlining transit and significantly improving logistics efficiency.

Sustainability will remain a key priority for the future of India's warehousing sector. As the country advances its commitment to global environmental objectives, warehouses are expected to adopt more eco-friendly infrastructure practices—emphasizing energy efficiency, renewable energy integration, and waste reduction. Frameworks like those from the Indian Green Building Council (IGBC) are likely to become the standard for sustainable warehouse design

In summary, India's warehousing industry is on the cusp of a transformative shift. Standardization will help resolve many of the sector's current challenges, from infrastructure inefficiencies and safety risks to labour issues and regulatory complexities. A unified approach to warehousing standards will enhance operational consistency, improve safety, and boost global competitiveness. As a crucial component of India's logistics framework, the modernization of warehousing through standardization will be vital to building a resilient, efficient, and future-ready supply chain ecosystem.

The e-Handbook on Warehousing Standards (2025) is a critical initiative aimed at transforming warehousing practices in India. Commissioned by the Ministry of Commerce and Industry through its Logistics Division, the handbook was developed in collaboration with industry experts, regulatory authorities, and logistics professionals to address the pressing need for unified standards in the warehousing sector. Given the central role warehousing plays in India's logistics and supply chain ecosystem, this comprehensive guide seeks to enhance operational efficiency, reduce costs, and facilitate integration with global logistics networks.

At its core, the handbook consolidates national and international best practices, offering a standardized framework for warehouse developers, operators, and logistics service providers. Its objective is to establish consistent benchmarks across safety, sustainability, and operational efficiency. The 2025 edition features updated content, including dedicated sections on the National Logistics Policy, automation, artificial intelligence (AI), and practical case studies that offer actionable insights into emerging technologies and practices. Each chapter is structured with clear objectives and expected outcomes, enabling stakeholders to understand the relevance and practical application of the standards.

The handbook covers a broad spectrum of warehousing functions, beginning with foundational infrastructure standards for construction, safety, and daily operations. These guidelines ensure compliance with national building codes and sector-specific regulations, with a strong focus on structural integrity, fire safety, and the integration of Warehouse Management Systems (WMS) and Industry 4.0 technologies. Additionally, standards for palletization, racking systems, and layout optimization are detailed to improve space utilization, enhance workplace safety, and boost productivity. Specifications for Material Handling Equipment (MHE) are also provided, aimed at reducing downtime, minimizing accidents, and increasing the longevity of critical equipment. Transportation connectivity standards promote seamless integration with multimodal logistics networks, including road, rail, and sea.

In response to rapid technological advancements, the handbook offers detailed guidance on the implementation of automation and AI solutions. It highlights tools such as Autonomous Mobile Robots (AMRs) and Automated Storage and Retrieval Systems (ASRS), which enhance productivity and enable data-driven decision-making. The incorporation of IoT technologies allows for the development of smart warehouses capable of dynamic, real-time operations.

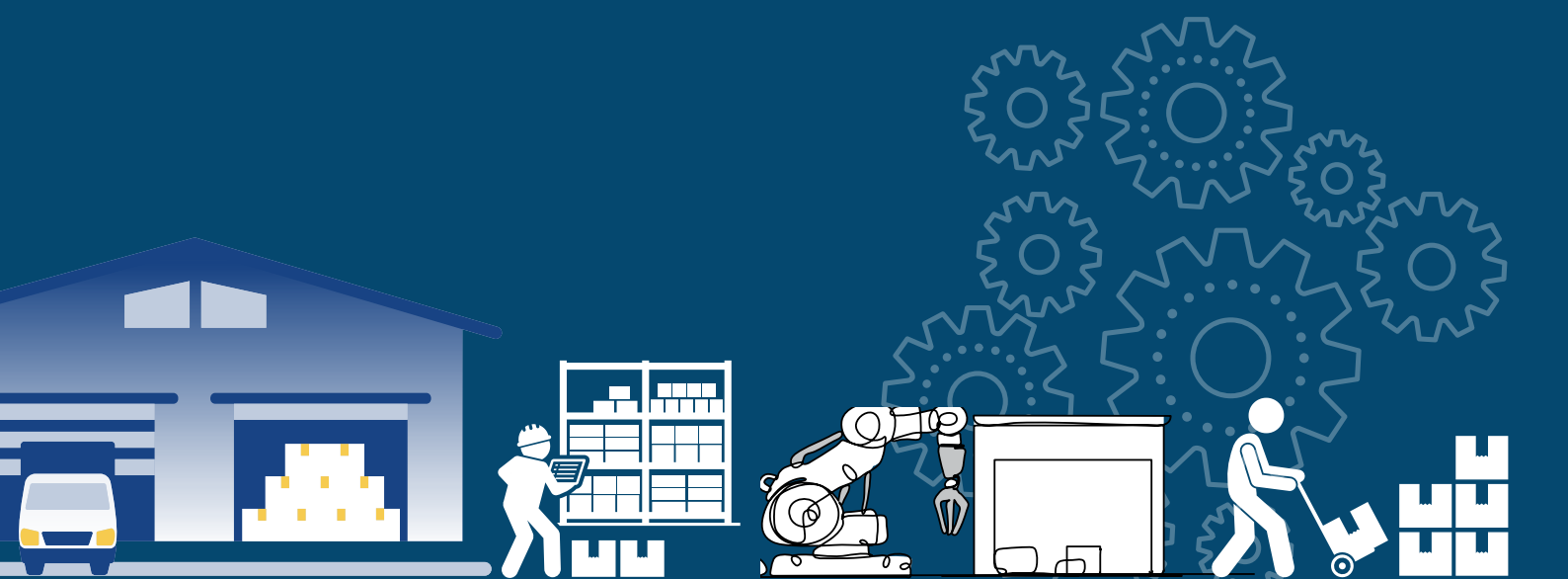
Sustainability is a core theme throughout the handbook. It advocates for energy-efficient infrastructure and adherence to green building certifications such as LEED and IGBC. These standards not only contribute to environmental conservation but also drive long-term cost savings and align Indian warehousing practices with international environmental commitments.

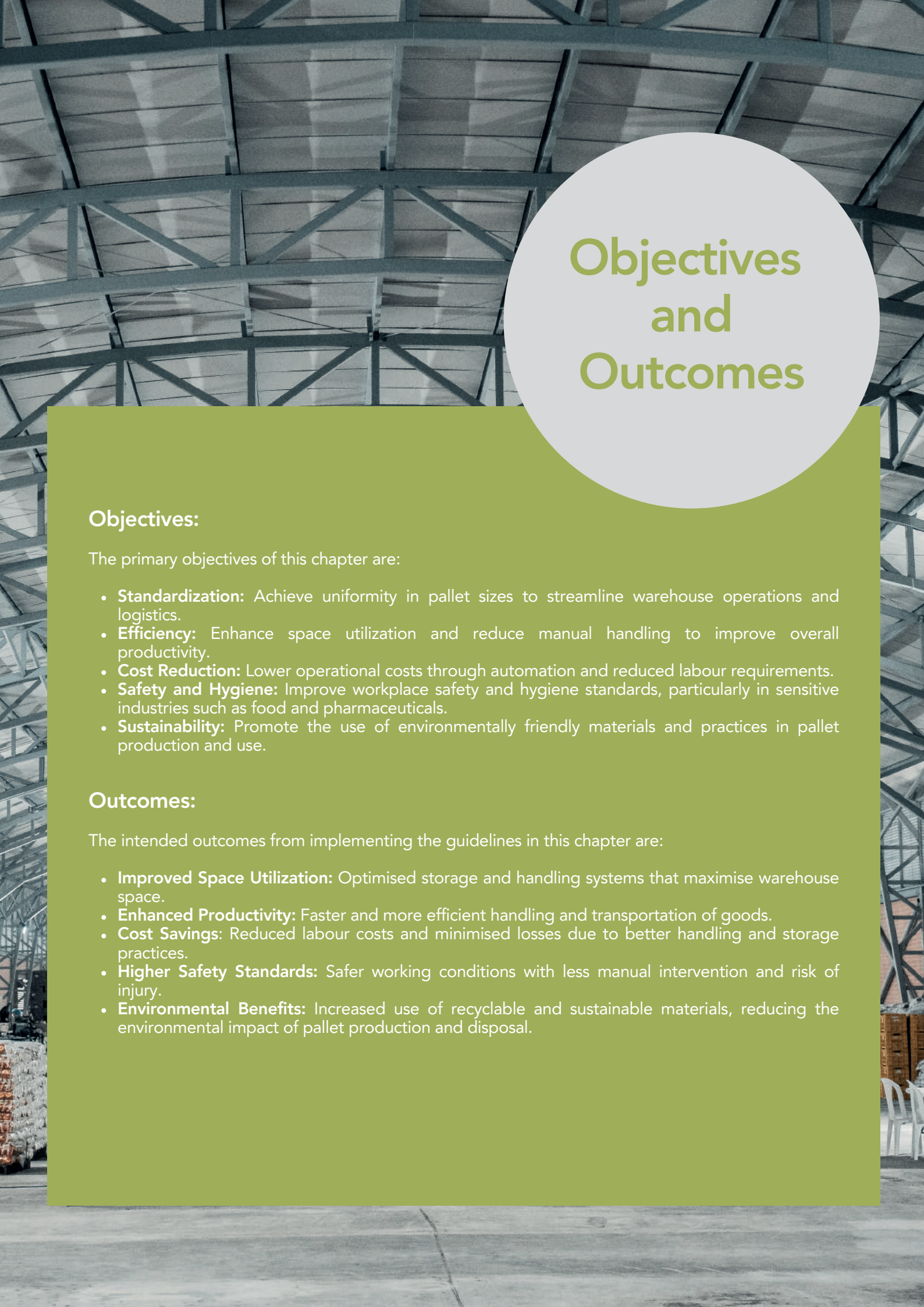
Furthermore, the handbook shares best practices adopted by various States/ UTs in their state logistics policies pertaining to warehouses that guides the creation of scalable, tech-enabled warehousing facilities that attract both public and private investment. Real-world case studies throughout the document demonstrate how companies have successfully implemented these standards to enhance performance, resolve operational bottlenecks, and embed sustainability into their core operations.

01

Infrastructure Standards

1. Warehousing planning and design
2. Logistics parks and warehouses
3. Warehouse flooring
4. Warehouse roofing
5. Maintenance
6. Warehouse machinery standards





Objectives and Outcomes

Objectives:

The primary objectives of this chapter are:

- **Standardization:** Achieve uniformity in pallet sizes to streamline warehouse operations and logistics.
- **Efficiency:** Enhance space utilization and reduce manual handling to improve overall productivity.
- **Cost Reduction:** Lower operational costs through automation and reduced labour requirements.
- **Safety and Hygiene:** Improve workplace safety and hygiene standards, particularly in sensitive industries such as food and pharmaceuticals.
- **Sustainability:** Promote the use of environmentally friendly materials and practices in pallet production and use.

Outcomes:

The intended outcomes from implementing the guidelines in this chapter are:

- **Improved Space Utilization:** Optimised storage and handling systems that maximise warehouse space.
- **Enhanced Productivity:** Faster and more efficient handling and transportation of goods.
- **Cost Savings**: Reduced labour costs and minimised losses due to better handling and storage practices.
- **Higher Safety Standards:** Safer working conditions with less manual intervention and risk of injury.
- **Environmental Benefits:** Increased use of recyclable and sustainable materials, reducing the environmental impact of pallet production and disposal.

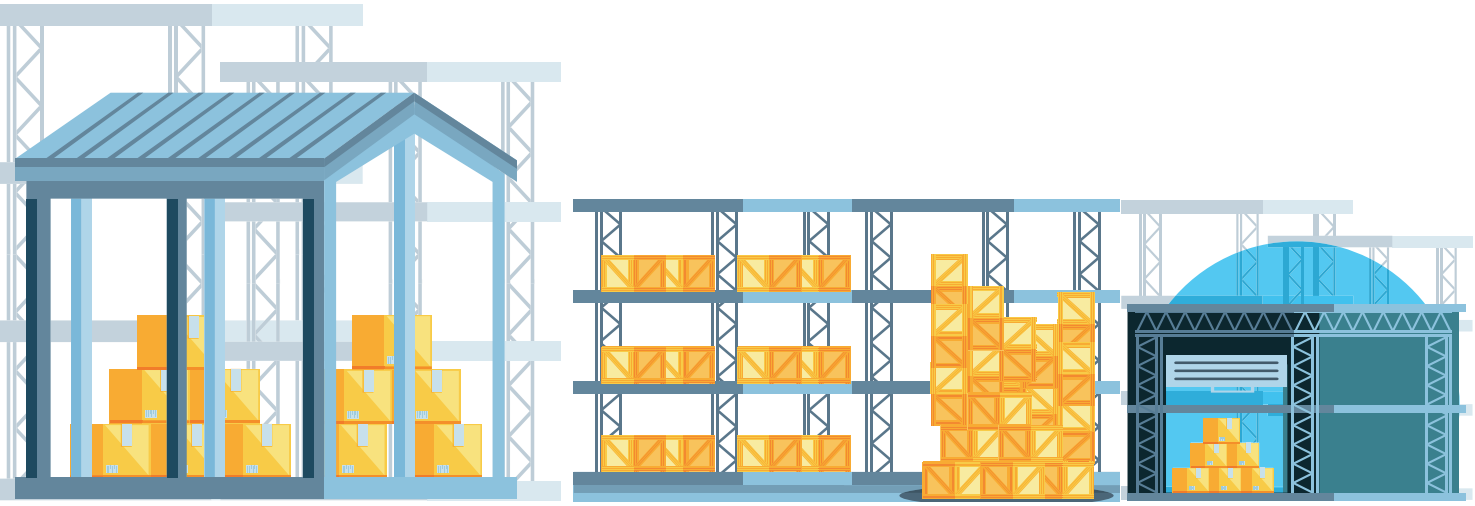
Introduction

Warehouses are a critical component of the supply chain and have seen significant improvements in their structures and specifications over the years. However, these advancements have often occurred without a structured set of guidelines or standards. The rising demand for warehousing space has led to substantial growth in new logistics parks and standalone warehouses, developed by large and medium-sized developers, self-users, and manufacturers. These developments have often been based on market demands or self-requirements, constructed according to the developers' understanding.

Over the past decade, the emergence of built-to-suit warehouses and large logistics parks has become increasingly common, driven by domestic and multinational companies, e-commerce businesses, and a growing influx of foreign direct investment from international developers. This trend has helped improve warehousing standards in the country, as many end-users and developers have adopted these standards when specifying their requirements for building or leasing warehouses.

Despite these advancements, there remains a need for a set of guidelines and standards for warehousing space development that are tailored to India's unique context. These guidelines must consider occupiers' requirements for storage and efficient operations, local conditions, economic feasibility, and regulatory compliance.

This chapter provides functional specifications and guidelines for building construction and planning, covering essential elements such as building maintenance, fire safety, security, flooring, roofing, and ventilation. The objective is to guide readers on the technical and functional standards necessary to ensure that warehouse buildings meet best-in-class Indian standards, comply with regulatory requirements, are sustainable, and are functionally suitable for a diverse range of end-users across various industry sectors.



1.1 Warehouse Planning and Design

Effective warehouse planning and design are critical to ensuring operational efficiency, safety, regulatory compliance, and scalability. A well-designed warehouse minimises travel time, enables smooth material flow, supports automation, and allows for future expansion. The planning process must be aligned with the warehouse's intended use, product types, throughput, and business model (e.g., e-commerce fulfilment, B2B distribution, agri-storage, etc.).

1.1.1 Site Selection

Choosing the right site forms the foundation of all subsequent design and operational decisions. Key criteria include:

- **Proximity to Transport Infrastructure:** Access to national and state highways, ports, railheads, and intermodal terminals is critical for minimising transportation costs and transit times.
- **Availability of Utilities and Amenities:** Reliable access to power, water, waste disposal, and telecom networks is essential. Proximity to fuel stations, repair workshops, and workforce housing enhances operational ease.
- **Topography and Soil Conditions:** Flat terrain with good drainage reduces site development costs. Soil-bearing capacity must support the intended structure without excessive piling.
- **Regulatory Approvals and Land Use:** The site must conform to local zoning norms (industrial, logistics, or warehousing use) and allow for building plan approvals, fire safety clearances, and environmental NOCs.
- **Community and Environmental Impact:** Social acceptance and low environmental risk (e.g., no floodplains, protected zones, or forest encroachments) reduce compliance delays.

1.1.2 Master Planning and Layout Design

The internal layout must reflect the functional flow of goods and people within the warehouse. Key components include:

- **Zoning:**
  - Inbound: Unloading bays, staging areas, quality inspection zones.
  - Storage: Block stacking, pallet racking, shelving, or ASRS zones.
  - Outbound: Order picking, packing, dispatch, and vehicle docks.
  - Support Areas: Offices, staff amenities, maintenance workshops, and utility rooms.
- **Material Flow Logic:**
  - Layouts must support the operating model (e.g., flow-through for fast-moving goods, U-shaped for limited access sites).
  - Material flow should be unidirectional where possible to reduce conflict points and improve safety.
- **Circulation and Access:**
  - Designated paths for MHE, workers, and visitors.
  - Separation of heavy vehicle movement (trailers, trucks) from two-wheeler or pedestrian areas.
  - Adequate turning radius and queuing space at gates and docks.
- **Site Infrastructure:**
  - Security posts, weighbridges, fire water tanks, and ETP/STP units.
  - Charging bays for electric MHE and provision for solar installations.

1.1.3. Structural Planning

The core structure must be engineered for durability, safety, and operational compatibility.

- **Clear Height:**
  - A minimum clear height of 10–12 meters is common in high-bay warehouses, allowing for efficient racking and automation (e.g., ASRS systems).
  - Clear height impacts HVAC design, lighting, and racking type.

- **Column Grid:**
  - Wide column spacing (e.g., 12m x 24m) improves manoeuvrability for forklifts and maximises usable storage volume.
  - Grid layout must align with pallet racking designs and fire aisle requirements.

- **Flooring:**
  - Floors must be laser-leveled and designed for high point loads and MHE traffic.
  - Standard loading ranges from 5–10 tons/m². Floor joints should be minimised to reduce wear on MHE.

- **Roof Design:**
  - Roofing must accommodate insulation, solar panels, and skylights. Ridge ventilation, smoke exhaust, and rainwater harvesting should be factored in.
  - Brownfield structures should be assessed for solar retrofitting based on roof integrity and anchoring methods.

1.1.4. Loading/Unloading and Dock Design

Efficient dock planning is critical for turnaround times and worker safety.

- **Dock Ratio:**
  - Typically, one dock per 8,000–10,000 sq. ft. of storage area, adjustable based on SKU profile and volume throughput.

- **Dock Equipment:**
  - Integration of dock levelers, seals, dock lights, wheel chocks, and bumpers ensures safe and efficient transfer of goods.

- **Grade-Level Access:**
  - Provision for side loading, drive-in ramps, or grade access is useful for small trucks or mixed-mode operations.

- **Staging Areas:**
  - Dedicated zones adjacent to docks for short-term holding of inbound and outbound materials help decouple storage from dispatch operations.

1.1.5 Scalability and Future-Proofing

A warehouse should not be designed solely for today's operations. Good planning anticipates future business growth, technology adoption, and sustainability mandates.

- **Modular Expansion:**
  - Provisions for phased expansion (e.g., pre-approved FAR, building grid continuity) should be integrated into the master plan.

- **Technology Readiness:**
  - Conduits and power backbones for future ASRS, AMRs, conveyors, and smart systems.
  - Wi-Fi and sensor network coverage plans for full-site digital readiness.

- **Sustainability Integration:**
  - Load-bearing capacity for rooftop solar, daylighting features, passive cooling, and EV infrastructure should be considered from the outset.
  - Green building features like stormwater recharge, native landscaping, and building envelope efficiency can be built into design stage specifications.

1.2 Warehousing Structures in Logistics Parks

As the logistics industry evolves, there has been a notable shift towards the development of logistics parks. These large-scale, planned facilities offer a range of services and infrastructure, catering to the increasing demand for efficient supply chain management. Logistics parks typically feature multiple warehouse units and provide comprehensive support for storage and distribution activities. Warehouses in general can be classified based on their physical structures, which include:

- Conventional brick-and-mortar buildings
- Cold storage and temperature-controlled warehouses
- Structural steel buildings
- Pre-engineered steel buildings
- Cover and Plinth storage
- Silos
- Open yards or depots
- Storage tanks and underground storage

1.2.1 Structural Standards for Warehouse Construction

In developing logistics parks and individual warehouses, it is essential to adhere to the mandatory standards set by regulatory bodies, such as:

- **National Building Code of India (NBC) 2016 provisions for Group H – Storage and Warehousing Occupancy Guidelines, including Part 6 'Structural Design':** Outlines provisions for storage and warehousing occupancy, including structural design requirements. Compliance ensures the safety and efficiency of warehouse structures.

- **Warehousing (Development and Regulation) Act, 2007,** and subsequent rules and regulations framed thereunder by the Warehousing Development and Regulatory Authority, including Warehousing (Development and Regulation) Registration of Warehouses Rules and Warehousing and Regulatory Authority (Electronic Negotiable Warehouse Receipts) Regulations, 2017. This act provides a legal framework for warehouse construction and operation, mandating adherence to specific standards for warehousing facilities.

- Standards / Guidelines for Warehouses listed in **Annexure 01.**

- **The Bureau of Indian Standards** and other standardization bodies specific to the design/construction and maintenance of structures are listed in **Annexure 02**.

- **Annexure 02** also provides a comprehensive infrastructure checklist for open areas, parking, and dock infrastructure, covering all regulatory and best-practice aspects.

BEST-IN-CLASS PRACTICES FOR WAREHOUSE CONSTRUCTION

National Standards

- Standards by the National Centre for Cold Chain Development.
- CAP Storages: BIS Guidelines for Improvement of Existing Structures Used or Intended to be Used for food grain storage (IS 609:2020), Dunnage pallet warehousing (IS 13714:1993), and guidelines issued by FCI, CWC Grain Marketing Corporation.

Standards for Temperature-Controlled Storage and Transportation

- IS 6028: 2002/ISO 931:1980 Green bananas Guide to storage and transport (Second Revision)
- IS 6669: 2001/ISO 1212:1995 Apples – Guide to cold storage (First Revision)
- IS 6670: 2018 Storage of potatoes - Guidelines (First Revision)
- IS 7191: 2001/ISO 5524:1991 Tomatoes - Guide to cold storage and refrigerated transport (First Revision)
- IS 7192: 1974 Guide for storage of citrus fruits
- IS 7252: 2013/ISO 2169: 1981 Fruits and vegetables - Physical conditions in cold stores - Definitions and measurement (First Revision)
- IS 7730: 1975 Guide for storage of pears
- IS 7731: 1975 Guide for storage of peaches
- IS 9303: 1979 Guide for cold storage of table grapes
- IS 9304: 1979 Guide for storage of mangoes
- IS 9311: 2001/ISO 1673:1991 Onions – Guide to storage (First Revision)
- IS 11966: 1997/ISO 6663:1995 Garlic – Cold storage (First Revision)
- IS 16118: 2013/ISO 6665: 1983 Strawberries - Guide to cold storage
- IS 16119: 2013 ISO 7562: 1990 Potatoes - Guidelines for storage in artificially ventilated stores
- IS 16120: 2013/ISO 5525: 1986 Potatoes - Storage in the open (In Clamps)

International Standards for Underground and Tank Storage

- Underground Storages: Guidelines specified by the American Petroleum Institute (API), including RP 1604 (Closure of Underground petroleum storage tanks), RP 1615 (Installation of Underground Petroleum storage tanks), RP 1631 (Interior lining and periodic inspection), and RP 1632 (Cathodic protection of underground tanks). Additionally, guidelines under National Leak Prevention Association Standards for Entry, Cleaning, Repair of Underground Storage Tanks (NLPA Std 631), Steel tank standards for liquid storage and underground tanks (STIR892, STI SP031, STI R942).
- Storage Tanks: Guidelines under the International Tanker Container Organisation, American Petroleum Institute (API), American National Standards Institute, and ISO standards for corrosion protection (IS 16961:2015).

These best-in-class practices ensure that warehouse construction meets the highest standards for efficiency, safety, and sustainability, catering to the diverse needs of the industry.

1.3 Warehouse Flooring

Floor slabs in warehouses and distribution centers are vital to the facility's efficient operation. They serve as the foundational surface for all activities. While they may seem straightforward, their design and construction involve complex considerations.
To ensure the creation of high-quality, durable floors that meet the operational needs of a warehouse, a comprehensive understanding of the key aspects involved in the design, execution, and maintenance of these floors is essential. This section outlines the fundamental considerations and specifications for warehouse flooring, providing a thorough guide to achieving optimal floor performance.

Key Aspects

1. **Approach to Floor Design:** This includes defining loads, selecting suitable materials, and detailing specifications to meet operational needs. Proper design ensures the floor can support various load types, including modern material handling equipment (MHE) and automated storage and retrieval systems (ASRS). It is advised that the building be fully enclosed before starting floor construction to protect the quality and integrity of the materials and workmanship.
2. **Execution Methodology:** A high-performing, durable floor results from a combination of engineering design, detailing, quality materials, skilled manpower, and superior workmanship. The construction process should adhere to best practices and standards.
3. **Selection Criteria for Flooring Partners:** Engaging the right designers and specialist contractors is essential to ensure that the floor meets all operational and design requirements.
4. **Decision Making / Responsibility Matrix:** Establishing a clear matrix for decision-making and responsibility is crucial. It defines the roles and responsibilities of all stakeholders involved in the project.

Relevant Standards:

- **IS 456:** Design and quality of reinforced concrete.
- **BS 8204:** Screed and base flatness for industrial flooring (FM1–FM3 classification).
- **TR34:** Floor design guide for robotic or automated warehouses.

1.3.1 Parameters for High-Performance Floors

This section provides an overview of the parameters for high-performance floors. It covers the key components of a high-performance floor, including the sub-base, sub-grade, slip membrane, concrete, floor design, reinforcement, and load transfer/floor joints. The section also guides the design and construction of each component, as well as recommendations for materials and construction methods.

a. Sub-base and Sub-grade:

a. Sub-grade: The initial layer forms the bulk of the earth filling and helps bring the building to grade level. This layer is cost-effective but critical, requiring proper compaction to avoid settlement issues. The sub-grade should be compacted in 200 mm-thick layers, compacted to a thickness of 150 mm. Sub-grade should be measured by proctor density and/or a plate load test.

b. Sub-base: This layer transfers loads to the sub-grade and must be well-compacted. It supports construction traffic and enhances soil stiffness. The success of the floor depends largely on the stability of this layer, requiring careful construction and supervision. The sub-base should also be compacted in 200 mm-thick layers, compacted to a thickness of 150 mm. Sub-base should also be measured by proctor density and/or a plate load test.

b.Slip Membrane:
A slip membrane reduces friction between the sub-base and the floor slab, allowing for independent movement. The slip membrane must be used to ensure that the floor is isolated from the sub-base to allow for movement. A double-layer slip membrane may be used if recommended by a specialised floor consultant.

c. Concrete:
The concrete used must ensure workability and serviceability. As a warehouse floor, also referred to as a slab on grade, is not a structural member of the building, workability and serviceability characteristics are prioritized over mechanical properties. Concrete with fly ash content should be avoided.

d. Floor Design:
Traditionally, floor loads were primarily considered as uniformly distributed loads (UDL). However, the advent of advanced material handling equipment (MHE) and automated storage and retrieval systems (ASRS) has necessitated a more comprehensive approach to load definition.

Definition of Loads: Modern requirements include various load types, such as:

1. **Point Load:** Determined by the size and contact area of the load, such as the baseplate size and load on the leg of a racking system.
2. **Dual Point Load:** Considered as a single load when point loads are in proximity.
3. **Line Load:** Applied where conveyor belts or assembly lines are installed.
4. **Dynamic Load:** Includes moving loads, primarily from MHE. Design must consider the all-up weight, axle, and individual wheel loads of MHE.

e.Reinforcement:
Suitable steel reinforcement in the form of rebar, steel, or plastic fibers should be used to reduce the concrete's cross-section. The rebar or fiber reinforcement should be designed by a floor consultant or a design-build flooring contractor.

f. Load Transfer / Floor Joints:
Control and construction joints are vital for the floor's durability and ease of operation. It is mandatory to have armored joints at all major crossings of MHE and their wheel movements to protect the arris of the joints. Load transfer of joints is done via the use of plate/diamond dowels. Joints must be placed based on concrete supply capability and the flooring contractor's ability to complete the panel on time before the concrete hardens. A pouring plan should be intelligently prepared to avoid consecutive panels being poured one after the other. These control and construction joints should be opened and refilled after 12 to 18 months with modified epoxy hybrid/semi-rigid epoxy. The sealant used should be manufactured by reputable manufacturers with proven results.

g. Floor Screeding Methods:
Laser-operated screed machines provide efficiency and precision. For smaller warehouses (less than 5,000 square meters), a truss screed system with proper camber arrangements can be used if a laser-operated screed machine is not available. The Vacuum Dewatered Floor (VDF) method, also known as Tremix, should be avoided where vertical storage with heavy MHE operations will be installed.

h. Sealants:
Sealants prevent debris and moisture ingress while supporting joint movement. It is best practice to use polyurethane sealant in control and construction joints during the construction stage.

i. **Floor Surface Regularity:**
Floor surface regularity is defined based on the racking height, MHE type, and movement. For stringent requirements where the racking height is greater than 7 meters, it is imperative to involve an experienced design-build flooring contractor or a flooring consultant in the design, decision-making, and execution processes. Floor surface regularity must be measured by a certified floor survey company with equipment suitable for the required methodology for surface regularity checks. Manual methods such as line dori or water stagnation are inadequate for this purpose.

1.3.2 Floor Protection Systems

This section provides an overview of different methods for protecting and enhancing concrete floors through floor curing, abrasion resistance, densification and polishing, and floor resin coatings.

a. Floor Curing: Floor curing is an extremely important process in increasing the life of the floor. Proper curing is either done by providing and spraying a water-based curing compound or by water curing with a plastic sheet. The method of water curing with LDPE sheets should be used for projects where a later-stage floor protection system such as densification, polishing, or resin coating is being planned. Curing mats may also be considered as temporary floor protection.

b. Abrasion Resistance – Hardeners: Floor hardeners are cement-based products that are incorporated monolithically into a floor during the construction process. Hardeners drastically improve wear, tear, and impact resistance, resulting in floors that are highly abrasion-resistant, easy to clean, and maintain.

c. Densification and Polishing: Densification seals microscopic pores in the concrete floors, creating a dust-proof floor and increasing hardness. Polishing enhances the floor's appearance and cleanliness. Nano/lithium/sodium sealers can be used for densification and polishing. These methods are used for floor protection and should not be considered a replacement for floor hardeners.

d. Floor Resin Coatings: Resin coatings protect floors exposed to adverse conditions, such as high temperatures or thermal shock. They come in epoxy, polyurethane (PU), and cementitious forms. PU is preferred for its technical advantages and longevity. The selection criteria for coatings include:

1. Performance Needs: Chemical and mechanical exposure, temperature/thermal shock resistance.
2. Functional Needs: Moisture insensitivity, safety (slip resistance), hygiene, and conductivity.
3. Advantages: Improved service life, no operational downtime or cost for refurbishment if treated during construction.

1.3.3 Post-Handover Guidelines & Maintenance

This section outlines the essential guidelines for the usage and maintenance of concrete floors to ensure their longevity and performance.

a. Usage & Loading Guidelines:

1. **Initial Curing Period:** Avoid any foot traffic or movement on the concrete slab for the first 7 days. Do not use scissor lifts or heavy equipment on the slab for the initial 28 days.
2. **Load Restrictions:** Adhere to the maximum load limits specified in the load calculation sheet for material handling equipment (MHE) and other moving machinery.

b. Maintenance Program:

1. **Regular Cleaning:** Maintain good housekeeping practices. Regularly clean the floor using a soft cleaning pad, water, or a neutral cleaner. Sweep and mop the floor to preserve the original finish.
2. **Spill Management:** Promptly clean up any acidic spills to prevent damage to the concrete. Avoid oil spills and consider using protective coatings like epoxy.
3. **Surface Protection:** Employ protective sheets under heavy machinery or sharp tools to safeguard the floor's surface from damage and pitting.
4. **Cleaning Agents:** Use only neutral cleaning agents. Avoid harsh chemicals, detergents, and hard brushes that can scratch the surface. Choose soft cleaning pads or microfiber pads for deep cleaning and maintaining the floor's shine.

Adherence to these standards ensures high-quality, durable warehouse floors that meet operational requirements. Refer to **Annexure 03** for detailed design parameters and standards, including guidelines per BS:8204 for metal deck, composite deck, and structural screed surface regulations.

1.4 Warehouse Roofing

This section details the standards and best practices for warehouse roofing, focusing on compliance with Indian and international regulations to ensure safety, durability, and energy efficiency.

1.4.1 Standards

The roofing standards primarily align with the American Iron and Steel Institute (AISI) and ISO guidelines. In India, the following standards are applicable:

a. Indian Standards:

- IS 875 – Part I: Dead Loads
- IS 875 – Part II: Imposed Loads
- IS 875 – Part III: Wind Loads
- IS 875 – Part V: Special Loads and Load Combinations
- IS 800: Code of Practice for General Construction in Steel
- IS 801: Code of Practice for Use of Cold-Formed Light Gauge Steel Structural Members in General Building Construction

b. American Institute of Steel Construction (AISC) Design Codes: For built-up sections and hot-rolled sections.

c. Metal Building Manufacturers Association (MBMA) 2012 Standards: Including the Cold-Formed Steel Design Manual (2017).

BEST-IN-CLASS PRACTICES FOR WAREHOUSE ROOFING

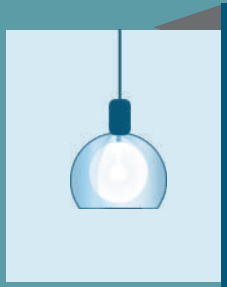
In addition to the above standards, implementing the following best practices can enhance the quality and functionality of warehouse roofing:

Roof Design and Construction

- Use roofing materials with a high Solar Reflective Index (SRI) to minimise heat gain.
- Ensure the roof assembly meets Energy Conservation Building Codes (ECBC), with a U-value not exceeding 0.33 W/m²K.
- Apply high SRI paints or use metal roof sheets with SRI values above 70 to further reduce heat gain.
- Consider a green roof, covering at least 50% of exposed roof areas, including open spaces and covered parking.
- Design roofs with screwed down, standing seam, or screw bolt sandwich panels to prevent leakage. Include roof insulation and side cladding to maintain internal temperatures at least 5-6 degrees Celsius cooler than the outside.
- Provide roof safety lifelines along the entire roof perimeter and on both sides of the roof monitor.
- Install rainwater gutters made of FRP-lined GI sheets outside the building at both eave sides. Ensure no water drainage lines are inside the warehouse, and design gutters and downpipes to handle rainfall intensity of at least 90 mm/hour. Protect downpipes from damage using bollards or curbstones.
- Include roof-access systems with vertical fall arrestors, cages, and locking arrangements at diagonally opposite corners for maintenance access.

Roof Ventilation

- Implement a louver ventilation system to facilitate at least six air changes per hour through the roof monitor, with louvers in wall cladding on all sides for air intake.
- Utilise ridge and turbo ventilators if they can meet the required air changes, avoiding turbo ventilators on standing seam roofs to prevent leakage at joinery points.
- If a roof monitor is not feasible, install force ventilation systems to achieve the necessary air changes.

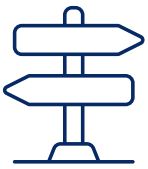


Roof Illumination:

- Ensure sufficient daylight for at least 50% of regularly occupied spaces, achieving daylight illuminance levels between 110 Lux and 200 Lux under clear sky conditions at 12 noon.
- Include enough skylights to minimise the need for artificial lighting during the day. The Indian Green Building Council (IGBC) recommends skylights covering at least 5% of the roof area, with potential increases based on specific needs.

1.5 Safety, Security, and Environmental Provisions in Warehousing

1.5.1 Signage



Signage is a crucial yet often overlooked component of warehouse assets. It provides essential information to users and visitors, reducing reliance on memory and enhancing efficiency in daily operations. The primary purposes of signage in a warehouse are:

a. To Provide Information
b. To Offer Assistance or Guidance
c. To Provide Warnings

To ensure clarity, signage should adhere to a specific color scheme based on the type of information conveyed:

- Mustard background with black text: Location/Information
- Blue background with white text: Information/Guidance/Location Tags
- Red background with white text: Warning
- Black or green background with white text: Operating Area Information

Design guidelines for signage are detailed in **Annexure 04**.

1.5.2 Fire Safety

All warehouse structures, regardless of type or products stored, must comply with the following fire safety standards:

- National Building Code of India (NBC) Part 4: Establishes guidelines for fire safety, including fire prevention, fire protection, and life safety.
- IS 3594: BIS Code of Practice for Fire Safety in Industrial Buildings, including guidelines for general storage and cold storage warehouses.
- IS 15683: Specifies requirements for portable fire extinguishers, including types, performance, and testing.
- IS 15105: Provides guidelines for the design and installation of automatic roof fire sprinkler systems.
- IS 13039:2014 (R2019): Standards for the design and installation of external fire hydrant systems.
- IS 3844:1989 (R2015): Guidelines for the design and installation of internal fire hydrant systems.

1.5.3 Security

The following standards are prescribed to ensure adequate security at warehouse premises:

- NBC of India 2016: Part 4 (Fire and Life Safety) and Part 12 (Asset and Facility Management) provide comprehensive guidelines for ensuring safety and security in warehouses.
- IS 16910: Standards for video surveillance systems used in security applications.

BEST-IN-CLASS PRACTICES FOR WAREHOUSE SECURITY

- Implement security standards specified by the Transport Asset Protection Association (TAPA) to safeguard goods.
- Install comprehensive surveillance systems, including CCTV cameras and monitoring stations, to ensure continuous oversight.
- Develop and enforce Standard Operating Procedures (SOPs) for security personnel, including protocols for theft, unauthorised entry, damage to goods, and disaster response.
- Use BIS-compliant surveillance equipment to ensure high-quality and reliable security measures.

BEST-IN-CLASS PRACTICES FOR OCCUPATIONAL SAFETY AND HEALTH

- Adhere to Occupational Safety and Health Administration (OSHA) guidelines to maintain a safe working environment.
- Implement the IS/ISO 45001 Occupational Health and Safety Management System to ensure comprehensive workplace safety.

BEST-IN-CLASS PRACTICES FOR SUSTAINABILITY

- Implement quality management systems, environmental management systems, and energy management systems as per:
  - IS/ISO 9001: Quality Management Systems
  - IS/ISO 14001: Environmental Management Systems
  - IS/ISO 50001: Energy Management Systems
- Follow the guidelines of Leadership in Energy and Environmental Design (LEED) or Indian Green Building Council (IGBC) for sustainable building practices.

1.5.5 Illumination

Adequate warehouse lighting is crucial for safety, efficiency, and productivity. Proper illumination prevents accidents, improves worker morale, and enhances operational performance. Selecting and installing suitable lighting equipment is essential to achieve optimal light levels while minimising energy consumption and maintenance costs.

Standards: Warehouses must comply with Part 8 of the National Building Code of India, which provides standards for building services, including illumination.

BEST-IN-CLASS PRACTICES FOR ILLUMINATION

- Adhere to IS 3646 (Part 1): Code of Practice for Interior Illumination, which outlines the requirements for lighting levels and quality.
- Implement adequate lighting measures, as specified by OSHA (1915.82), to ensure optimal illumination for safe operations while minimising energy consumption and maintenance costs.
- Utilise LED lighting fixtures, which are eco-friendly and energy-efficient, to reduce electricity consumption and improve sustainability.

1.6 Warehouse Machinery Standards

With technological advancements, modern warehouses utilise a variety of machinery and handling equipment, including cube containers, robotic systems, drone-based solutions, and more. These advancements necessitate updated standards to ensure safety, efficiency, and compliance. The machinery used in warehouses is typically categorised into several groups:

- Docking Equipment: Includes dock levellers, dock seals, and shelters.
- Storage Equipment: Consists of pallet racks, multi-tier shelving, long-span shelves, etc.
- Lifting Equipment: Encompasses stackers, reach trucks, hand pallet trucks, articulated forklifts, cranes, and forklifts.
- Conveyors: Utilised for efficient material movement.

Additionally, warehouses employ lighting equipment, safety signage, and other safety measures such as rails, ramps, and emergency lights. The following standards should be adhered to for these equipment categories:

1. **Handling Equipment Standards:** The specifications, dimensions, testing, and stability of handling equipment such as forklifts, trailers, and other transport machinery must comply with the following Bureau of Indian Standards (BIS):

2. **Conveyor Systems Standards:** For the selection and design of conveyor systems in large warehouses, the following BIS standards should be followed:
    i. IS 11592: Specifies criteria for the selection and design of belt conveyors.
    ii. IS 14188: Provides design parameters for maintenance facilities in conveyor systems.

These standards and best practices ensure that warehouses are equipped with the latest and most efficient machinery, enhancing overall safety, productivity, and operational efficiency.

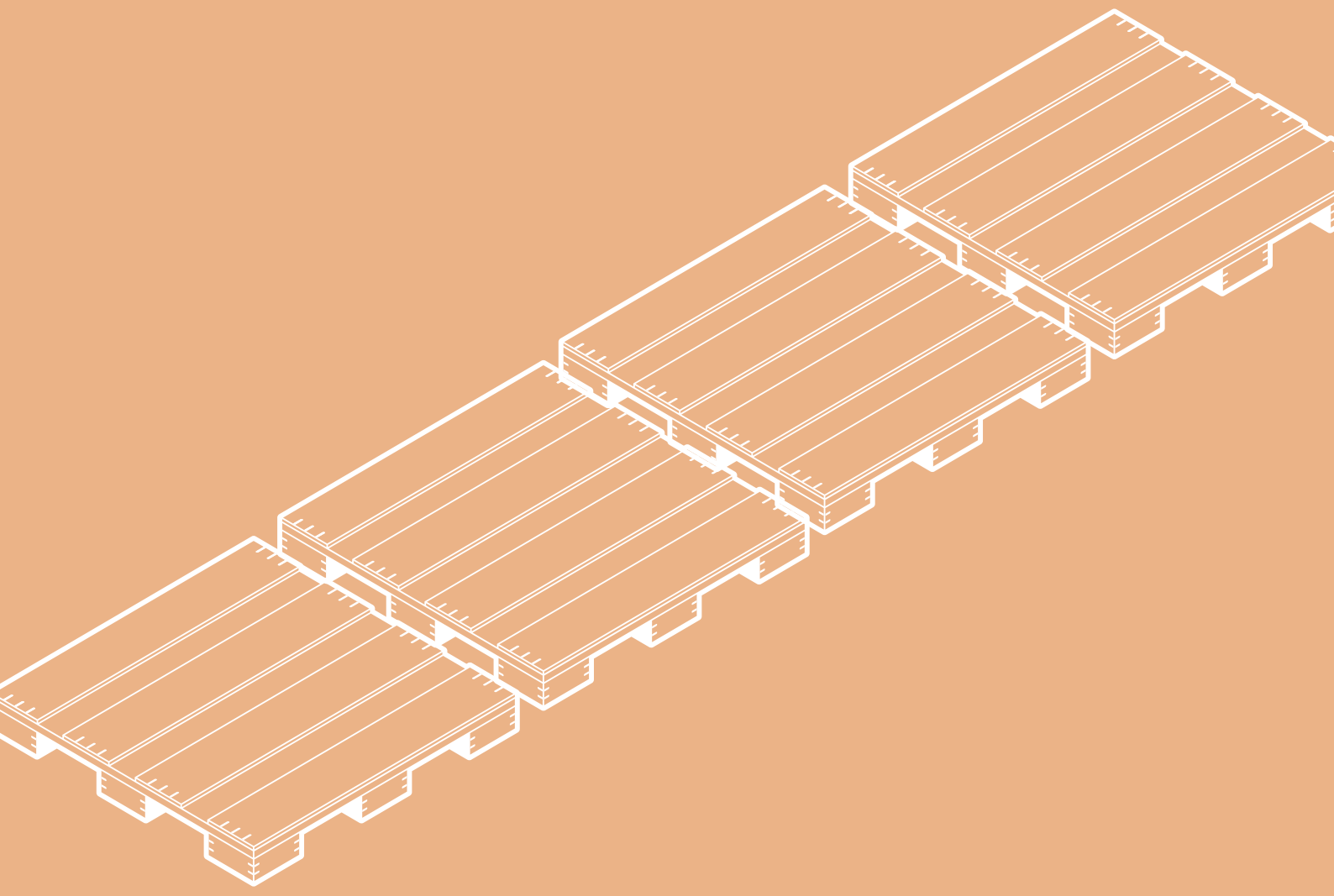
Standard Number	Name	Brief Description
IS 1057	Text Signs and Symbolic Signs for Public Information	Provides guidance on the design and use of textual and symbolic signage used to convey public information in a clear, accessible, and standardized manner.
IS 10312	Code of Practice for Industrial Lighting	Provides detailed guidelines for the design, installation, and maintenance of lighting systems in industrial premises, including warehouses, factories, and workshops.
IS 10517	Acceptance Criteria for Fork-Lift Trucks	This standard provides comprehensive guidelines for the acceptance testing of forklift trucks, ensuring that they meet the necessary safety, performance, and design criteria before being put into operation.
IS 10312	Safety Code for Powered Tow Trucks	This standard provides guidelines for the safe operation, maintenance, and design of powered tow trucks used in industrial and commercial settings.
IS 11683	Code of Practice for Design, Operation and Maintenance of Warehouse Lighting	Provides comprehensive guidance for the lighting of warehouses, covering aspects such as design parameters, operational requirements, and maintenance practices.
IS 11757	Code of Practice for Fire Safety of Industrial Buildings: General Storage and Warehousing	Provides a comprehensive framework for fire safety in industrial buildings specifically used for general storage and warehousing.
IS 12726	Code of Practice for Selection, Operation and Maintenance of Industrial Trucks	Provides comprehensive guidelines for the safe selection, operation, and maintenance of industrial trucks, including forklifts, pallet trucks, stackers, and other powered or manual material handling vehicles commonly used in warehouses, factories, and industrial premises.
IS 13302	Code of Practice for Ventilation in Warehouses	Provides detailed guidance on the design and implementation of ventilation systems in warehouses to ensure: adequate air quality, thermal comfort for workers, preservation of stored goods, and prevention of moisture buildup, mould, or heat-related degradation.
IS 13971-1	Requirements for Ventilators for Buildings – Part 1: Light Duty Ventilators	Specifies the technical requirements and performance criteria for light-duty ventilators used in buildings, including warehouses, factories, and other industrial or commercial facilities.
IS 13971-2	Requirements for Ventilators for Buildings – Part 2: Heavy Duty Ventilators	Lays down the requirements for the design, construction, performance, and installation of heavy duty ventilators used in industrial and large commercial buildings, including warehouses, factories, and logistics hubs.
IS 14770	Pallet for Materials Handling – Principal Dimensions and Tolerances	Defines the standard dimensions, tolerances, and specifications for pallets used in materials handling operations, particularly in warehouses, factories, and logistics environments.
IS 15487	Industrial Trucks – Specification for Indicator Lights for Container Handling and Grappler Arm Operations	This standard specifies the requirements for indicator lights used to show the status of freight-container-handling spreaders and grappler arms.

Standard Number	Name	Brief Description
IS 15488	Powered Industrial Trucks – Safety Signs and Hazard Pictorials – General Principles	This standard provides guidelines for the design and application of safety signs and hazard pictorials on powered industrial trucks.
IS 15611-1	Fire Protection — Fire Detection and Alarm Systems — Part 1: System Design, Installation, and Servicing	Specifies the requirements and guidelines for the design, installation, and servicing of fire detection and alarm systems.
IS 15611-2	Single Side Loading Fork Lift Trucks — Part 2: Stability Tests	This standard outlines the procedures and requirements for conducting stability tests on single side loading fork lift trucks.
IS 15634	Fork-lift Trucks – Forks-Arm Extensions and Telescopic Fork-Arms – Technical Characteristics and Strength Requirements	This standard specifies the technical characteristics and strength requirements for fork-arm extensions and telescopic fork-arms used in fork-lift trucks.
IS 4357	Methods for Stability Testing of Fork Lift Trucks	This standard outlines the procedures for assessing the stability of fork lift trucks under various operational conditions.
IS 6876	Fork-Lift Trucks — Fork Arms — Technical Characteristics and Testing (Second Revision)	This standard provides comprehensive guidelines for the design, manufacturing, testing, and marking of solid-section fork arms used in forklift trucks.
IS 7309	Reach and Straddle Forklift Trucks – Method of Stability Test	This standard provides guidelines for conducting stability tests on reach and straddle forklift trucks.
IS 7525	Mounting Dimensions for Fork Carriers and Fork Arms for Forklift Trucks	This standard specifies the dimensions and additional requirements for fork carriers and hook-on type fork arms used in forklift trucks. It ensures the interchangeability of fork arms and other attachments, considering the truck's rated capacity and type of fork arm.
IS 7570	Fork Arms and Attachments of Fork Lift Trucks – Glossary of Terms	This standard provides a comprehensive glossary of terms related to fork arms and attachments used in forklift trucks.
IS 7617	Code of Practice for Maintenance of Forks for Forklift Trucks	This standard provides guidelines for the inspection, maintenance, and repair of solid-section fork arms used in all types of forklift trucks.
IS 8790-2	General Requirements of Powered Industrial Trucks Working in Hazardous Areas – Part 2: Electric Battery-Powered Industrial Trucks	This standard outlines the safety and design requirements for electric battery-powered industrial trucks intended for use in hazardous areas.
IS 15640	Bi-Directional and Multi-Directional Fork-Lift Trucks – Stability Tests	This standard specifies the basic tests to verify the stability of bi-directional and multi-directional fork-lift trucks, whether equipped with tiltable or non-tiltable masts or fork arms.

02

Palletization Standards

1. Palletization Overview
2. Pallet Standards
3. Best-in-Class Palletization Standards



Objectives and Outcomes

Objectives:

The primary objectives of this chapter are:

- **Standardization:** Achieve uniformity in pallet sizes to streamline warehouse operations and logistics.
- **Efficiency:** Enhance space utilization and reduce manual handling to improve overall productivity.
- **Cost Reduction:** Lower operational costs through automation and reduced labour requirements.
- **Safety and Hygiene:** Improve workplace safety and hygiene standards, particularly in sensitive industries such as food and pharmaceuticals.
- **Sustainability:** Promote the use of environmentally friendly materials and practices in pallet production and use.

Outcomes:

The intended outcomes from implementing the guidelines in this chapter are:

- **Improved Space Utilization:** Optimised storage and handling systems that maximise warehouse space.
- **Enhanced Productivity:** Faster and more efficient handling and transportation of goods.
- **Cost Savings**: Reduced labour costs and minimised losses due to better handling and storage practices.
- **Higher Safety Standards:** Safer working conditions with less manual intervention and risk of injury.
- **Environmental Benefits:** Increased use of recyclable and sustainable materials, reducing the environmental impact of pallet production and disposal.

Introduction

In the logistics and warehousing industry, palletization plays a crucial role in achieving operational efficiencies. Standardizing pallet sizes can significantly impact the entire logistics cycle, allowing for the standardization of palletizers, racking systems, material handling equipment, truck load beds, and containers. This leads to better space utilization and facilitates automation, which in turn reduces manual labour, enhances productivity, and minimises losses and wastage. This document provides a comprehensive overview of palletization, types of pallets, materials used, relevant standards, and best practices for optimize warehouse operations.

2.1 Palletization Overview

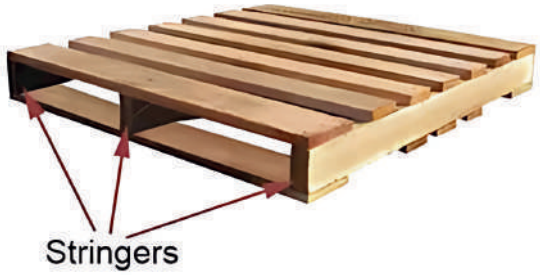
Palletization is essential for achieving efficiency in warehousing and logistics standardizing pallet sizes enables the alignment of associated equipment and processes—such as palletizers, racking systems, material handling equipment, truck beds, and containers—thereby improving space utilization and supporting automation. This standardization reduces the need for manual handling, increases operational efficiency, and minimises losses and waste.

2.1.1 Pallet Types

A pallet is a unit load device (ULD) - a rigid frame on which goods are placed and moved using Material Handling Equipment (MHE). Pallets are commonly classified into several types. The choice of pallet type depends on factors like the industry, load requirements, storage conditions, and transportation methods.

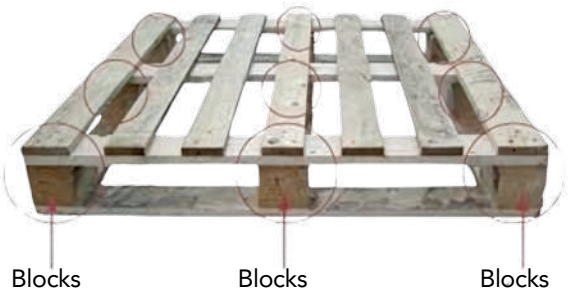
1) Stringer Pallets: The most commonly used pallet type, featuring three or more parallel timber supports called stringers. These provide a stable base for deckboards and allow forklift entry from two or four sides, depending on the design.

- **Two-way Stringer Pallets:** Allow entry of material handling equipment (MHE) from only two opposite sides, making them simpler but less versatile.
- **Four-way Stringer Pallets:** Feature notches on all four sides, enabling MHE access from any direction, offering greater flexibility in handling and storage.



2) Block Pallets: Constructed using solid blocks or cubes of wood, plastic, or other materials at the corners and center, block pallets offer enhanced strength and load stability. Their design typically allows four-way entry for MHE, making them highly maneuverable and suitable for heavy-duty applications.

- **Two-way Block Pallets:** Designed to allow material handling equipment (MHE) entry from only two opposite sides, limiting maneuverability.
- **Four-way Block Pallets:** Feature openings on all four sides, enabling MHE access from any direction for easier handling and improved efficiency.



3) Perimeter Base Pallets:

These pallets feature a continuous base with runners along all sides, offering enhanced stability and even weight distribution. They allow four-sided access for material handling equipment, making them ideal for heavy or uneven loads.

4) Reversible Pallets:

Designed with identical top and bottom decks, these pallets can be used with either side facing up. This provides greater flexibility in handling, stacking, and storage operations.

5) Nestable Pallets:

These pallets are designed to fit into one another when empty, significantly reducing storage and transport space. Ideal for industries prioritizing space optimization and return logistics efficiency.

2.1.2 Pallet Material of Construction

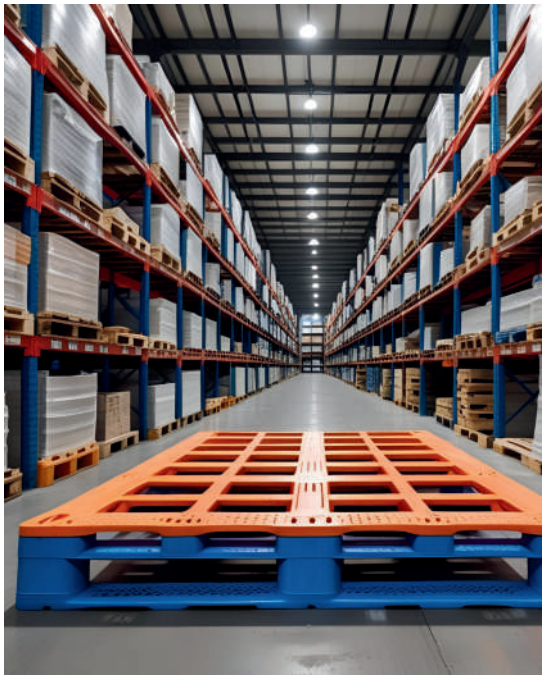
Pallets are also classified based on their material: **Wooden, Plastic, and Metal**

Wooden pallets-

Historically, wooden pallets have been more widely used and are still considered more popular in many industries for the following reasons:

1. **Cost:** Wooden pallets are less expensive than plastic pallets, making them a preferred choice, especially for one-way shipping or industries with high pallet turnover.
2. **Availability:** Wooden pallets are widely available and can be easily repaired or recycled. They are often readily accessible and can be sourced locally in many regions.
3. **Strength and Load Capacity:** Wooden pallets are known for their strength and ability to handle heavy loads. They are commonly used in industries such as logistics, warehousing, and manufacturing, where robustness is crucial.
4. **Sustainability:** While wooden pallets are made from a renewable resource, they can contribute to deforestation and require ongoing maintenance. However, they are often recycled and repurposed, reducing waste.

Plastic Pallets-



Nevertheless, plastic pallets are gaining popularity for specific applications and industries due to their unique advantages:

1. **Hygiene and Cleanliness:** Plastic pallets are resistant to moisture, chemicals, and bacteria, making them suitable for industries like pharmaceuticals, food and beverage, and healthcare. They can be easily cleaned and are less prone to contamination.
2. **Durability:** Plastic pallets are more durable than wooden pallets and have a longer lifespan. They can withstand harsh environments, extreme temperatures, and repeated use without splintering or warping.
3. **Lightweight:** Plastic pallets are lighter than wooden pallets, reducing transportation costs and making them easier to handle.
4. **Consistency:** Plastic pallets offer standardised dimensions and weight, ensuring consistency in automated handling systems and reducing the risk of damage to goods.

It is worth noting that there is a growing trend toward sustainability and environmental consciousness. As a result, the use of plastic pallets made from recycled materials or bio-based plastics is increasing, making them a more environmentally friendly choice.

Metal Pallets-

Metal pallets are commonly used in heavy-duty applications and demanding environments, offering several distinct benefits:

1. **Extreme Strength:** Metal pallets, typically made from steel or aluminium, are capable of supporting very heavy loads and are suitable for use in environments requiring high structural integrity.
2. **Longevity:** These pallets are highly durable and resistant to impacts, corrosion (when coated), and environmental wear, making them ideal for long-term use in industries like automotive, military, and heavy manufacturing.
3. **Fire Resistance:** Unlike wooden or plastic pallets, metal pallets are non-combustible, making them suitable for fire-sensitive environments or regulations.
4. **Hygienic Surface:** Metal pallets have smooth surfaces that are easy to sanitize, suitable for sterile or controlled environments when hygiene is critical.

However, metal pallets are generally more expensive and heavier than other types, which can increase handling and shipping costs.

Cardboard Pallets-

Cardboard (or paper-based) pallets are a lightweight and eco-friendly option gaining traction in specific use cases:

1. **Lightweight Design:** Cardboard pallets are significantly lighter than wooden or plastic ones, leading to lower transportation costs and easier manual handling.
2. **Recyclability:** These pallets are made from recycled paper products and are fully recyclable, aligning well with sustainability initiatives and zero-waste goals.
3. **Customizability:** Cardboard pallets can be designed and fabricated to exact dimensions, ideal for one-time shipments and point-of-sale (POS) displays.
4. **Cost-Effectiveness for Short-Term Use:** For air freight and low-weight goods, cardboard pallets can offer a cost-effective, single-use solution.

Despite their advantages, cardboard pallets are not suitable for wet environments or heavy-duty applications and must be handled carefully to prevent damage.

2.2 Overall Comparison

While wooden pallets have been traditionally more popular, plastic pallets are gaining traction in specific industries due to their unique benefits. The choice between wooden and plastic pallets depends on the specific requirements, cost considerations, industry standards, and sustainability goals of the businesses involved.

Selection Criteria
Rather than choosing a pallet based solely on the lowest price, industries and logistics service providers should select a pallet that meets the need for:

- High stiffness
- Proper strength and size
- Durability
- Cleanliness
- Low weight

In the past, significant efforts have been made in the field of standardization of pallets, but a lot remains to be done. In the construction and design of any warehouse, accommodating standardised pallet dimensions is a key factor. This allows for optimization of workflow and efficient movement of inventory in and out of the plant or warehouses. Designing a warehouse to accommodate the correct pallet size represents huge financial savings for the industry.

2.3 Pallet Standards

The current standards governing palletization in India are specified by the Bureau of Indian Standards (BIS). Below is a summary of these standards, making it easier to understand their applications and requirements.

Mandatory Standards for Warehouse Facilities Using Pallets:

- **Palletization Standards:**
  - Specified under TED 24 of the Transport Engineering Department under BIS.
  - IS 509: Dimensions of hand pallet trucks.
  - IS 13609: Guidelines for the quality of timber in pallets.
  - IS 7631: Methods of stability testing for pallet stackers and high lift platform trucks.

2. Crates Standards:

- IS 8726: Standards for wire-bound wooden crates.
- IS 15532: Standards for plastic crates for fruits and vegetables.
- IS 10324: Standards for wooden crates for bottled drinks.

3. Export Standards for Pallets:

- IS 7073: Glossaries of terms related to air cargo pallets & containers.
- IS 13823: Guidelines for palletization – general cargo.

4. Recycled Material Standards:

- IS 16058: Dunnage pallets made from recycled plastic wastes for warehousing applications- Specification.
- IS 17427: Wooden (Timber) Pallets for Packaging, Storage, and Transportation- Specification.

ISO Standards Related to Pallets:

- ISO 445: Pallets for materials handling – Vocabulary.
- ISO 6780: Flat pallets for intercontinental materials handling – Principal dimensions and tolerances.

Additional Indian Standards on Pallets:

- IS 3971: Pallets for materials handling - Vocabulary (second revision).
- IS 4300: Box pallets for through transit of goods specification (first revision).
- IS 6865: Specification for pallets for use in ISO series 1 freight containers.
- IS 7276: Non-expendable general-purpose, flat pallets for through transit of goods- Specification (second revision).
- IS 7804: Guide for palletization of tea chests (first revision).
- IS 8005: Classification of unit loads.
- IS 8006: Recommendations for handling timber pallets (first revision).
- IS 9208: Guide for palletization of mica for export.
- IS 9340: Expendable pallets - Specification (first revision).
- IS 11076: Guide for palletization of cashew kernels for export.
- IS 11982: Design rating and safe working load for general-purpose flat pallets for through transit of goods.
- IS 11983: Guidelines for marking general-purpose flat pallets for through transit of goods.
- IS 13546: General-purpose flat pallets for through transit of goods - Performance requirements.
- IS 13714: Dunnage pallets - Warehousing.
- IS 13664: Poly pallets for bag storage godowns - Verification of stability (Second Revision).
- IS 8726: Wire-bound wooden crates.
- IS 7698: Returnable wooden crates for vegetables.
- IS 5247 Part 2: Converted timber (coniferous) - Packing cases and crates.
- IS 3071: Wooden crates.
- IS 15532: Plastics crates for fruits and vegetables.
- IS 13289: Polypropylene/impact copolymer (PPCP) crates for milk sachets.
- IS 11584: High-density polyethylene (HDPE) crates for milk sachets.
- IS 3971/ISO 445: Pallets for materials handling - Vocabulary.
- IS 13823: Guidelines for palletization - General cargo.

These standards ensure the quality, safety, and consistency of pallets used in various industries and applications, promoting efficient and sustainable practices in material handling and storage.

2.4 Best-in-Class Practices

Pallet Dimensions

- 1200mm x 1200mm: Used in chemicals and petrochemicals.
- 1000mm x 1200mm: Common in food & beverages, FMCG, retail, pharmaceuticals, electronics, and automotive industries.
- 800mm x 1200mm: Used in automotive and auto components.
- 1140mm x 1140mm: For international shipping in ISO containers.

Pallet Material Specifications

- Use certified or legally compliant timber (e.g., Indian Forestry Act, ISPM 15 compliant for imported lumber).
- Avoid treating pallets with toxic chemicals, especially for the food and beverage sector, per Indian Food and Safety Act 2008.
- Adopt a reduce, reuse, and recycle approach for all pallet materials.
- Refer to various international standards set by:
  - International Organisation for Standardization (ISO)
  - American Society for Testing and Materials (ASTM)
  - National Wooden Pallet and Container Association (NWPCA)

Nominal (mm)	Actual (mm)	Internal (mm)
300x200	297x198	243x162
400x300	396x297	346x265
600x400	594x396	544x364
800x600	800x600	752x552

Intermediate Bulk Container (IBC): Typically, IBCs have an average base dimension of 1143mm x 1143mm.

Drums with outer dimension of a 200-litre capacity would have the following dimensions:

Diameter		Height
Top / Bottom Rim	Chines (ridges around drum)	
584 mm	597 mm	876 mm

Pallet Stacking

- Rectangular stacks of 1000mm x 1200mm: Accommodate 10 boxes in 2 layers or 15 boxes in 3 layers.
- Rectangular stacks of 1200mm x 1200mm: Accommodate 12 boxes in 2 layers and 18 boxes in 3 layers.
- Rectangular stacks of 800mm x 1200mm: Accommodate 8 boxes in 2 layers and 12 boxes in 3 layers.
- Square stacks of 1200mm x 1200mm: Can take 4 standard-size drums.
- For more information on standards and best practices, refer to guidelines provided by:
  - International Organisation for Standardization (ISO)
  - American Society for Testing and Materials (ASTM)
  - National Wooden Pallet and Container Association (NWPCA)

Pallet Nomenclature

- **Industrial Pallet:**
  - Dimensions: 1000mm x 1200mm
  - Other Names: ISO pallet
  - Common Use: Widely used in Asia and North America.

- **Euro Pallet:**
  - Dimensions: 800mm x 1200mm
  - Usage: Most widespread in Europe.
  - Regulation: Managed by the European Pallet Association (EPAL). As per EPAL's website, approximately 500 million Euro pallets are currently in circulation.
  - Standardization: One of the pallet types standardised by the International Organisation for Standardization (ISO).
  - Advantages: Facilitates the flow of goods and their grouping in transport and storage processes.
  - Design Consideration: Measurements are based on the width of truck wagons, containers, and trailers, which are typically 2400mm. This allows for optimal utilization of load space.

- **Flat Board Pallet:**
  - Dimensions: 1200mm x 1200mm
  - Special Usage: Ideal for specific applications, such as the carriage of drums.

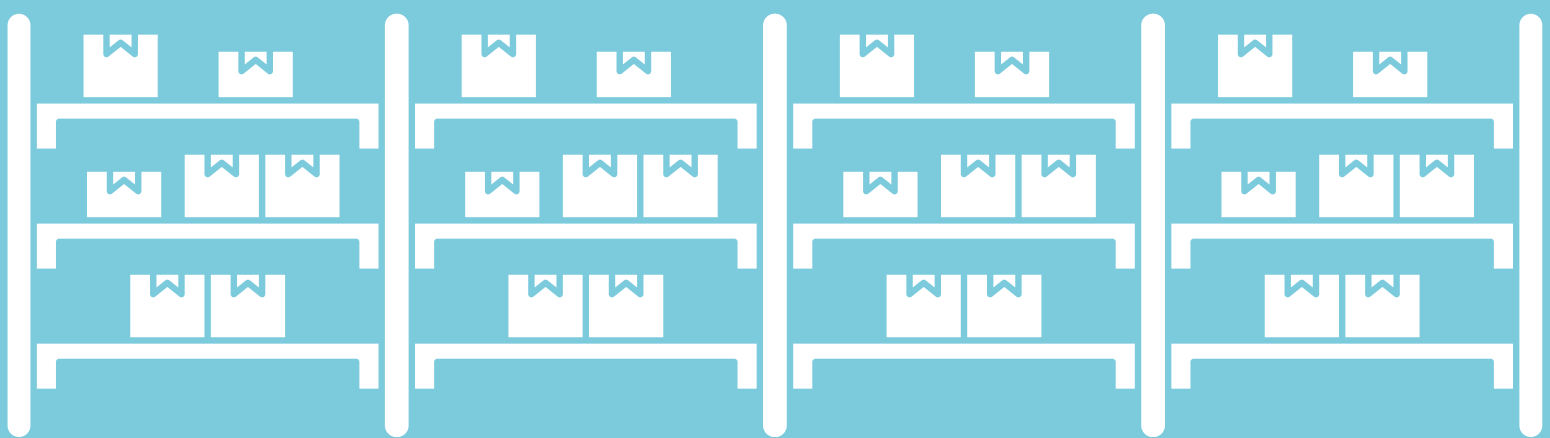
- **Additional Considerations**
  - Maintain paved roads and easy maneuverability for loading/unloading at warehouses.
  - Use Euro pallets for international cargo to ease handling at airports and seaports.
  - Train loaders to handle pallets with forklifts and pallet jacks, avoiding manual loading/unloading due to associated risks.

Use high-performance or pre-stretched pallet wrap to reduce material usage, and train staff on proper wrapping techniques to avoid waste. Standardize pallet sizes and stacking and avoid over-wrapping. To minimize or replace plastic wrap, consider sustainable alternatives like reusable wraps or straps, pallet bands, compostable films, or stretch hooding. For internal logistics, palletizing adhesives or corrugated interlayers can also eliminate the need for plastic wrap.

03

Racking Standards

1. Racking types
2. Racking selection guidelines
3. Raw material and design standards
4. Fasteners and anchors
5. Audit and maintenance



Objectives and Outcomes

Objectives:

The primary objectives of this chapter are:

- **Establish Design Guidelines:** Provide comprehensive design guidelines for racking systems in warehouses and distribution centres, ensuring safety and efficiency.
- **Standardise Racking System Specifications:** Define the specifications for various types of racking systems, considering the lack of specific Indian standards and referencing established European norms.
- **Enhance Safety and Durability:** Recommend best practices for the selection of materials, surface finishes, and protective elements to ensure the long-term durability and safety of racking systems.
- Establish Maintenance and Audit Procedures: Outline standards for the inspection, maintenance, and end-of-life disposal of racking components, ensuring compliance with safety and environmental standards.

Outcomes:

The intended outcomes from implementing the guidelines in this chapter are:

- **Increased Efficiency:** Optimised racking systems that maximise storage capacity and facilitate efficient inventory management.
- **Improved Safety:** A reduction in accidents and equipment damage through the implementation of safety features and regular maintenance protocols.
- **Standardised Practices:** Uniformity in the design and implementation of racking systems across facilities, promoting best practices and consistent quality.
- **Sustainability:** Environmentally responsible disposal of racking components, contributing to sustainability goals and compliance with regulations like Restriction of Hazardous Substances (RoHS).

By adhering to these objectives and outcomes, the chapter aims to enhance the overall operational efficiency and safety of warehousing operations in India.

Introduction

Racking systems are vital components of warehouses and distribution centres, playing a crucial role in the materials storage and handling industry. These systems are designed to stack materials in horizontal rows across multiple levels, enhancing the cube capacity utilization of warehouses by maximizing vertical space.

The design and placement of racks depend on the selectivity needs of SKU, storage density, and operational speed, which influence the choice of material handling equipment. There are various types of racking systems, including:

- Selective Pallet Racking
- Double Deep Racking
- Mobile Racking
- Satellite Racking
- Drive-In Racking
- Pushback Racking
- Pallet Live Racking
- Narrow Aisle Racking
- Cantilever Racking
- Multi-Tier Shelving System
- Automatic Storage and Retrieval Systems
- Pallet Shuttle Systems

3.1 Applicable Products and Scope

Each type of racking system offers unique benefits tailored to specific storage needs and operational requirements. Understanding the range and scope of these systems is crucial for selecting the most suitable options for your facility. This section outlines the applicable products, and the scope of the standards and guidelines covered in this document. It specifies the types of racking and shelving systems included, as well as notable exclusions. The aim is to provide a clear understanding of what is covered in this document, enabling informed decision-making for efficient and safe storage solutions.

- Selective pallet racking, including double deep and carriage-mounted racks
- Shuttle racking
- Drive-in racking
- Mobile Pallet Racking
- Single-tier shelving systems
- Multi-tier shelving systems
- Mezzanine floors, single and multi-tier

Exclusions:

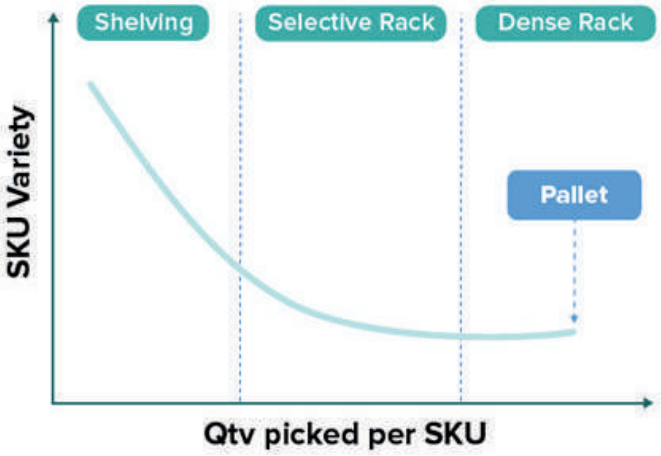
- Racks designed for stacker cranes and other automated equipment
- Earthquake-resistant design of racking systems

3.2 General Guidelines for Selecting Various Racking Systems

The choice of a racking system depends on the transaction density, i.e., the number of items picked per order.

For example:

- For minimal quantities, such as a single box, manual picking from a shelving system is ideal.
- For picking around 100 boxes, a selective pallet racking system is suitable.
- For larger quantities, like 1000 boxes (10 pallets per order), a dense system like shuttle or drive-in racking may be preferred.



3.3. Design Standards

India lacks specific standards for designing racking systems; hence, European standards are referenced. The following table can be referred for designing the various system. https://www.fem-rands.org/publications.

S. No.	Product	Applicable Standards
1	Selective pallet racking	EN 15512:2020
2	Drive in pallet racking	FEM 10.2.07
3	Shuttle pallet racking	FEM 10.2.19:2021
4	Shelving	FEM 10.2.07:2012
5	Mobile pallet racking	FEM 10.2.18:2023

3.4 Clearances in Design

The following recommended clearances for selective pallet racking ensure proper handling and prevent issues such as material overhang and SKU bulge.

Recommended Clearances		
Level Height (mm)	Side (mm)	Top (mm)
3000	100	100
6000	100	100
9000	100	125
12000	125	125

For shelving applications, it is recommended to maintain a minimum side clearance of 25 mm from the upright. Additional clearances should be determined on a case-by-case basis, considering the method of picking and the nature of the items being picked (whether picking involves a complete box/carton or individual items from within a box/carton). When picking a complete box/carton, ensure there is sufficient side clearance between boxes/cartons. If picking individual items from a box/carton, adequate top clearance between the box/carton and the bottom of the beam is essential. Refer to chapter on Material Handling Equipment for the right storage product.

Pallet width, mm	1000	1200
Number of pallets	2	2
Recommended beam span, mm	2300	2700

3.5 Raw Material Standards

In the construction and maintenance of racking systems, the choice of raw materials and their quality play a crucial role in ensuring the durability, safety, and overall performance of the structure. This section outlines the standards and specifications for the raw materials used in manufacturing racking systems, focusing on the essential properties and compliance requirements. It details the necessary characteristics of steel and surface finishes, emphasising the importance of using high-quality, compliant materials to withstand various operational and environmental conditions. By adhering to these raw material standards, facilities can achieve long-lasting and reliable racking systems that meet industry norms and safety regulations.

3.5.1 Steel

- Critical load-bearing members (uprights, beams, frame bracing, deck panels) should be made of "specified steels" conforming to minimum guaranteed mechanical properties specified in BIS/EN/DIN/ASTM/JIS standards (or equivalent).
- For structural calculations, only the minimum guaranteed yield strength specified for that grade of steel shall be considered and not the tested yield strength available for production.
- Increase in yield strength on account of cold working (during Roll forming, etc.) is permissible based on the design code used.
- Steel used should possess adequate ductility (10-20 % elongation) and a minimum gap of 10% shall be maintained between yield strength and ultimate tensile strength.
- RoHS-compliant steel is recommended to ensure environmental safety.

3.5.2 Surface Finish

The surface finish of rack components should be determined based on the following factors:

- **Environment:** The conditions in which the racks will be installed, such as dry or corrosive environments.
- **Type of SKU Stored:** The nature of the items stored, including whether they are non-corrosive or corrosive.
- **Operational Aspects:** The wear and tear components may be experienced during use.

For racks located in dry environments and storing non-corrosive items, standard protective coatings are sufficient. Both powder coatings and liquid painting are acceptable, provided that an appropriate pre-treatment process is employed to ensure proper surface preparation. The durability of the coating should be verified through suitable inspection methods.

In corrosive environments or for storing corrosive items, special attention must be given to the coatings to ensure they can withstand the conditions. Zinc coating is recommended for components subject to abrasion during operation, such as drive-in pallet rails, shuttle pallet rails, and walkway panels, depending on the suitability of the process.

All coatings must comply with RoHS (Restriction of Hazardous Substances) requirements.

3.6 Fasteners and Anchors

Given that racking structures are entirely bolted together, it is crucial to use the appropriate grade of fasteners. It is recommended to use grade 8.8 fasteners for assembling the structure. For anchoring base plates, mechanical floor anchors should be of grade 5.6. The size and number of anchors should be determined based on the configuration and load requirements of the system.

3.7 Suggested Flooring

Racking systems impose multiple point loads; thus, the floor design should account for these. For further details, refer to the chapter on Infrastructure Standards. Recommended slope and undulation:

- Maximum variation within 3mm across a 1000mm x 1000mm area.
- Overall floor variation within 10mm.

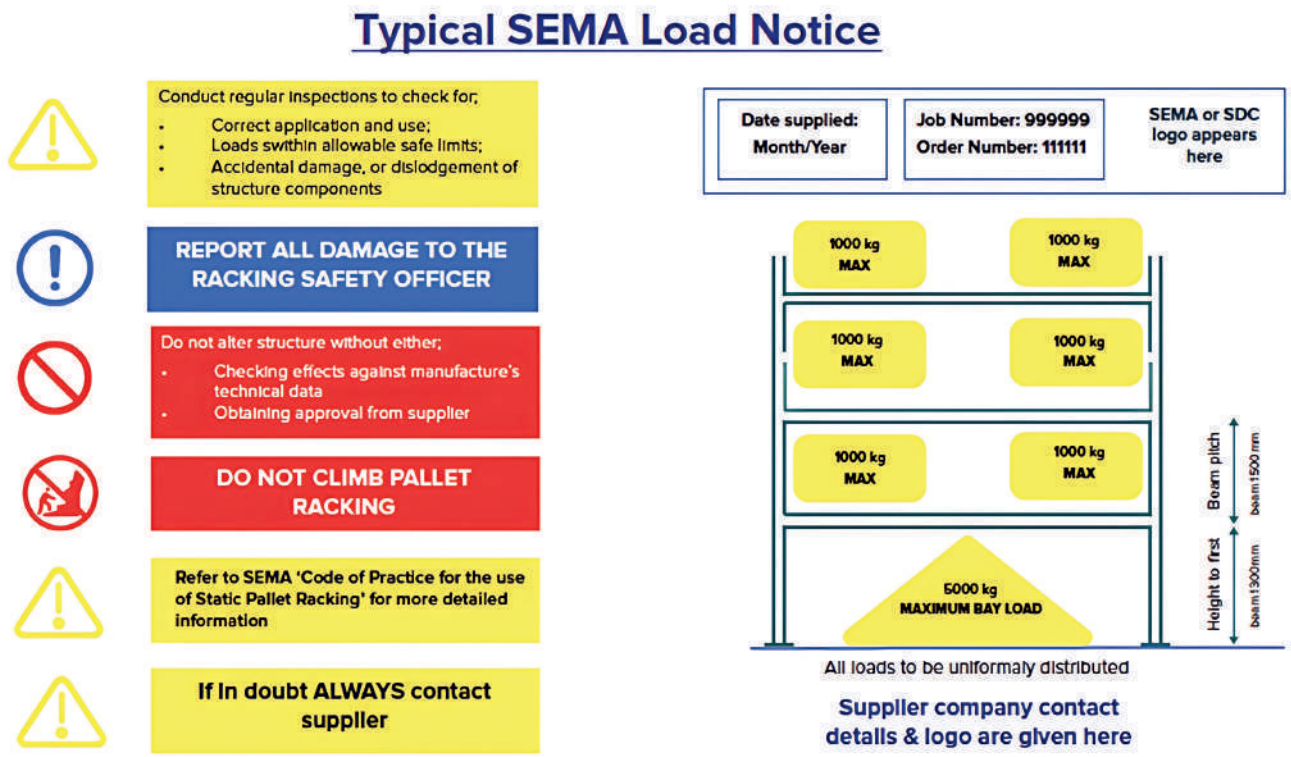
3.8 Safety and Suggested Accessories

Selecting the appropriate safety elements is essential to protect the system from accidental damage and ensure the safety of personnel working within the area. Some recommended practices include:

- Installing frame guards on all exposed frames along the sides of a cross aisle.
- Protecting both sides of an underpass unit with frame guards.
- Installing column guards on the first upright at the entry to an aisle.
- In some cases, protecting all aisle-facing uprights with column guards.
- Preventing pallet falls with a pallet back stopper.
- Installing back mesh to prevent SKUs from falling off the rack.
- Providing a protection mesh above the beam of an underpass unit.
- Guarding the corner uprights of a multi-tier system to prevent impacts from hand pallet trucks or trolleys.
- Installing MHE stoppers in front of shuttle racking systems.
- Installing guide rails inside a drive-in racking bay.

3.9 Standards for Audit and Maintenance

A Speed Equipment Manufacturing Association (SEMA) load notice must be displayed on all storage systems explaining to the end users of a racking system how the system should be used and system's limitations. Different racking systems have different load notices, but most follow a similar structure. A typical load notice outlines the need for regular racking inspection from a SEMA approved inspector, the need to adhere to the SEMA Code of Practice, and when to contact the supplier of the system. Load notices do not replace the need for employers to train their staff on the safe use of racking systems. The illustration below depicts a typical SEMA load notice.



Damage from bends to racking system shall be judged over 1-metre sections. Localised bends over a shorter length should be judged pro-rata, i.e. over a half metre length half the limit applies. Components subject to other damage such a tears and splits must be replaced. Inspections should be carried out from ground level with the visual examination of exterior and other reasonably accessible racking components. If any damaged racking is identified which requires immediate attention, the site contact should be informed of the racking component and its position in the racking installation. Following an inspection, racking will be categorised into three risks, green, amber and red.

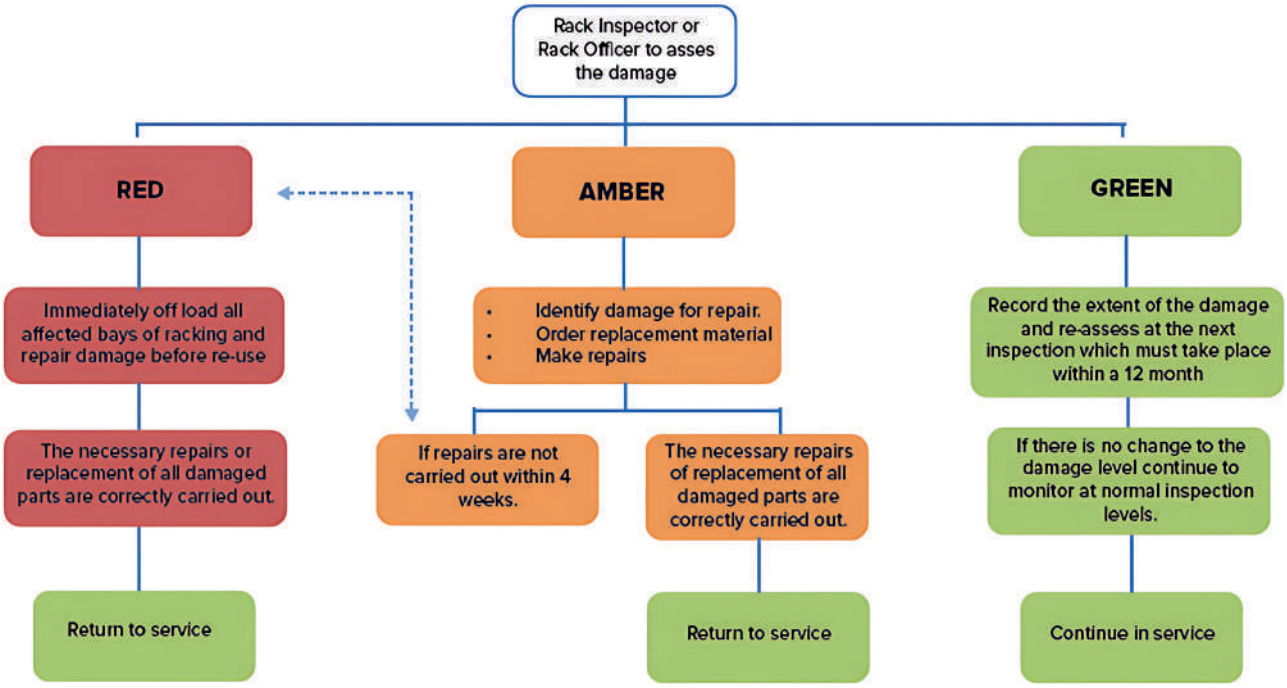
Green – areas where damage is sufficiently low to allow the continued use of the racking with no remedial action. It is good practice to continue to monitor the issue at subsequent inspections. Green risks can be useful in identifying patterns of damage and ascertaining the cause to prevent the escalation of damage.

Amber – areas where the damage exceeds permissible limits, warranting remedial work, but not enough to warrant the immediate unloading of the rack. The affected area or component should be offloaded as soon as possible and not reused until repairs or rectification have been applied. Amber escalates to Red if no action is taken within four weeks.

Red– areas where a high level of damage is identified well beyond permissible limits requiring immediate offloading and isolating from future use until repair work is carried out.

The table and flowchart below provide guidance on risk categorisation and follow up actions.

Risk Meter	Upright bent into the rack	Upright bent parallel to beam	Frame Bracing
Green	Upto 3 mm	Upto 5 mm	Upto 10 mm
Amber	Between 3 to 6 mm	Between 5 to 10 mm	Between 10 to 20 mm
Red	Over 6 mm	Over 10 mm	Over 20 mm

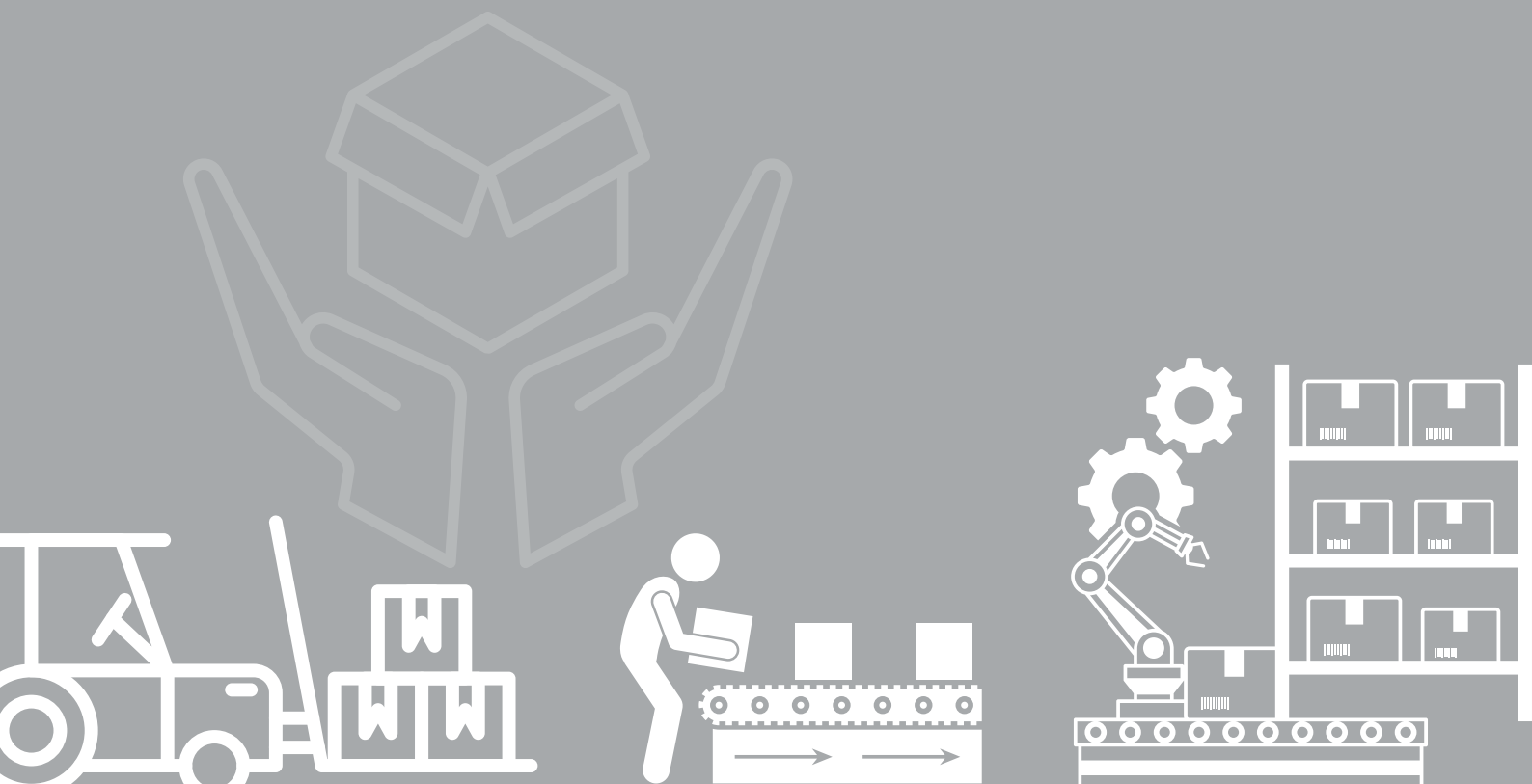


3.10 End of Life Disposal

Components should be designed and manufactured for environmentally friendly disposal, adhering to RoHS requirements for safety during recycling. Manufacturers should guide customers on responsible disposal methods

04 Material Handling Equipment Standards

1. Material handling equipment types
2. Certificate and compliance requirements
3. Standards and guidelines



Objectives and Outcomes

Objectives:

The primary objectives of this chapter are:

- **Clearly Articulate the Standardization Requirements:** Define the international and national standards applicable to Multi-Modal Handling Equipment (MHE) to ensure consistent application across industries and regions.
- **Enhance Compliance with Safety and Efficiency Standards:** Develop a comprehensive understanding of the safety protocols and operational efficiencies required in handling equipment to meet global regulatory standards.
- **Promote Innovation in MHE Design:** Facilitate the adoption of advanced technologies in MHE design to improve efficiency, safety, and adaptability to evolving supply chain needs.
- Provide a Framework for Global Interoperability: Establish a robust framework that supports the interoperability of multi-modal handling equipment across different geographies and logistics infrastructures.
- **Encourage Adoption of Best Practices:** Advocate for the integration of best practices in logistics and warehousing through standardised MHE, enhancing overall supply chain resilience and sustainability.

Outcomes:

The intended outcomes from implementing the guidelines in this chapter are:

- **Enhanced Knowledge of MHE Types and Applications:** Ability to identify and differentiate between various types of MHE and their specific uses in warehouse operations. Improved understanding of the operational capabilities and limitations of different MHE.
- **Improved Warehouse Efficiency and Safety:** Application of appropriate MHE for specific tasks to optimise workflow and reduce operational bottlenecks. Enhanced safety measures and reduced risk of accidents through adherence to safety guidelines and standards.
- **Compliance with Standards and Regulations:** Ensuring all MHE used in the warehouse meet the mandatory BIS standards and guidelines. Maintaining compliance with certification and emission norms for environmentally friendly and safe operations.
- **Optimised Material Handling Processes:** Streamlined material handling processes through the effective use of suitable MHE, leading to increased productivity. Efficient layout planning and racking system integration to accommodate specific MHE requirements.
- **Proactive Maintenance and Safety Management:** Implementation of regular maintenance schedules and safety checks as per OEM guidelines. Reduction in downtime and extended lifespan of MHE through proper maintenance practices.

By achieving these objectives and outcomes, warehouse operations can be significantly improved, leading to better productivity, safety, and compliance with industry standards.

Introduction

Warehouses rely on a variety of material handling equipment (MHE) to facilitate operations. Common equipment includes forklift trucks, stackers, reach trucks, articulated forklifts, man-up turret trucks, hand pallet trucks, battery-operated pallet trucks, cranes, robots, conveyors, and other dock automation equipment.

Importance of Material Handling Equipment
MHE play a crucial role in warehouse operations, starting from the receipt of raw materials to the dispatch of finished goods. Their primary objective is to ensure efficient handling at a safe speed while minimising human effort and fatigue. MHE are designed to integrate seamlessly with material storage systems, ensuring accurate, speedy, and safe loading, which enhances operational throughput and improves warehouse productivity.

Evolution and Standards
Historically, MHE were manually operated, but they have evolved into semi or fully automated systems. In India, the Bureau of Indian Standards (BIS) prescribes mandatory standards for MHE usage, including:

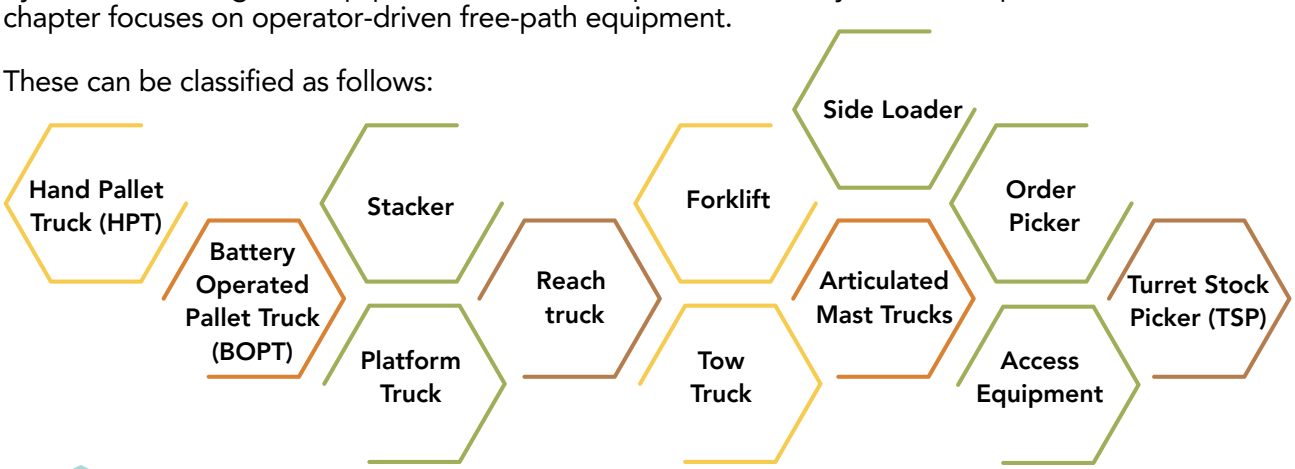
- IS 10517: Acceptance criteria for forklift trucks.
- IS 11757: General requirements and acceptance criteria for forklift trucks with a capacity of 10,000 kg to 50,000 kg.
- IS 4660: Powered industrial trucks terminology.

A comprehensive list of standards is provided in Annexure 05 – MHE Standards/Guidelines.

4.1 Types of Material Handling Equipment

Globally, material handling equipment usage is consistent and requires standardization. Selecting the right equipment for specific tasks improves warehouse efficiency. Material handling equipment includes trolleys, cranes, conveyors, forklifts, and more. These can be manually operated or powered by batteries or engines. Equipment can be fixed-path (like conveyors) or free-path (like forklifts). This chapter focuses on operator-driven free-path equipment.

These can be classified as follows:



Hand Pallet Truck (HPT)

A Hand Pallet Truck (HPT) is a manually operated tool used for ground-level movement of palletised loads. It allows lifting of loads slightly off the ground using a hydraulic mechanism and is moved by pushing or pulling manually.
Standard load capacity ranges from 2000 to 2500 kg. It is ideal for short-distance transport in warehouses and stockrooms.

Battery Operated Pallet Truck (BOPT)

A Battery Operated Pallet Truck (BOPT) is a motorized version of the Hand Pallet Truck, equipped with a battery, motor, and hydraulic pump for powered lifting and movement. It reduces manual effort and increases efficiency in material handling. Capacity typically ranges from 2000 to 3600 kg. Suitable for medium to large warehouses and logistics hubs.

Variants:
Operator Platform: Available in foldable or fixed types, with side-entry or rear-entry options for operator convenience and safety.

Fork Length: Ranges from 800 mm to 2400 mm, allowing the truck to carry one or two pallets simultaneously, depending on the load configuration.

Stacker

Pedestrian equipment for transporting and lifting palletised loads, used in block storage (palletised loads stacked one above another in 2 or 3 high configuration) or racking systems.

Types:

- **Manual:** All operations are manual; capacity 1000 kg at 600 mm load center; lift height 1600 – 2000 mm.
- **Semi-Electric:** Battery-powered lifting; manual movement; capacity 1000 kg at 600 mm load center; lift height 2400 – 3300 mm.
- **Fully Electric:** Battery-powered operations; capacity 1000 - 1500 kg at 600 mm load center; lift height 2500 – 6300 mm. Fully electric stacker is available in variants such as: Fork-over-straddle type, Wide-straddle-type, Counterbalance Stacker, and Stacker-with-reach. Each variant has specific characteristics and should thus be selected based on application as per guidance from manufacturer of such equipment.

Reach Truck

Reach trucks are battery-powered, compact alternatives to forklifts, ideal for smaller spaces. They lift loads from 1,000 to 2,500 kg to heights of up to 13 meters. Widely used across industries, reach trucks require good flooring for safety.

Key considerations for selecting a reach truck include load capacity and lift height. For instance, a 1-tonne load at 600 mm needing a 9-meter lift requires a 1.6-tonne reach truck. Always used indoors, they demand good flooring for smooth operation.
Reach trucks come in two main types: moving mast with a fixed seat or moving carriage with a pantograph mechanism and folding seat. They can also be single or double deep, depending on the racking system. Single-deep moving mast trucks can be converted to double deep using telescopic forks, while moving carriage trucks use a double pantograph for double-deep applications.

Forklift

Forklifts are indispensable in various industries due to their adaptability. Their robust construction, with solid or pneumatic tires, allows for both indoor and outdoor use. However, their large turning radius necessitates ample workspace.

Power Sources:

- **Internal Combustion Engine (ICE):** Powered by traditional fuels.
- **Electric: :** Battery-operated, offering quieter and cleaner operation. Available in 3-wheel (smaller turning radius) and 4-wheel variants.

Load Capacity:

- **Light Duty:** Suitable for loads ranging from 1 to 3 tons.
- **Medium Duty:** Designed to handle 3 to 6 tons.
- **Heavy Duty:** Capable of handling loads exceeding 6 tons, up to 25 tons or more.

Articulated Mast Trucks

Articulated mast trucks are battery-powered vehicles that combine the strengths of forklifts and reach trucks. Unlike forklifts, they don't require specialised flooring due to their larger wheels. Like reach trucks, they excel in narrow aisles while offering high lifting capacities.

Their unique articulated mast design enables operation in extremely narrow spaces as narrow as 1.8 to 2.2 meters. These trucks can handle loads up to 2,000 kilograms with a load center of 600 millimeters and can lift to heights of up to 12.5 meters.

Order Picker

Order pickers are specialised equipment for collecting individual items from storage, unlike pallet handling.

They range from simple trolleys to battery-powered trucks that elevate operators to high rack levels. Low-level order pickers handle up to 2000 kg with 2400 mm forks, while high-level models lift 1500 kg at 600 mm load center to 12 meters, requiring flat floors.
To boost efficiency, technologies like pick-to-light and pick-to-voice systems are employed, especially for ground-level picking.

Turret Stock Picker (TSP)

Turret stock pickers (TSPs) are battery-powered machines combining pallet storage and retrieval with order picking at height in racking systems.

They operate in very narrow aisles (VNA) of 1800-2000 mm and can handle base loads of 1000-1500 kg. Like stock pickers, TSPs require super flat floors for safety.

Wire or rail guidance systems are crucial for safe operation.

Side Loader

A side loader is a specialised piece of equipment designed to efficiently transport long, bulky materials like plywood or glass sheets while maximizing space utilization.

Available in both battery-powered and engine-powered variants, optimizing space and load stability.

Tow Truck

Tow trucks are versatile vehicles used across industries. They are commonly employed in automobile and textile plants to move material-laden trolleys efficiently.

With the capacity to tow multiple trolleys simultaneously, they enhance operational speed. Their applications extend to airports, where they handle baggage trolleys and even push back aircraft.

Both battery and engine-powered variants are available to suit diverse operational needs.

Platform Truck

This battery-operated equipment is used for carrying non-homogeneous loads up to a weight of 2 tonnes from one point to another. It is commonly used in railway workshops.

Platform Trucks are battery-operated vehicles designed for transporting non-homogeneous loads of up to 2 tonnes over short distances. Commonly used in railway workshops, manufacturing units, and warehouses, they ensure safe and efficient movement of diverse materials. Their flatbed design allows for easy loading and unloading, enhancing productivity in material handling operations.

Access Equipment

Access equipment is used for carrying people and tools for performing maintenance at heights. It can also be used for cycle counting or checking inventory at elevated locations.

This product replaces the need for manual staircases or personnel travelling in cages mounted on the forks of reach or forklift trucks.

Access equipment is offered in two variants:

1. Powered lifting and lowering with manual ground movement, and
2. Self-propelled, allowing the operator to drive the equipment even when elevated.

The following are some defined applications along with the corresponding material handling equipment within warehouses:

- **Docking:** Docking refers to the process or system managing the loading and unloading of goods at dock areas. Docking applications optimise the flow of goods between trucks or other vehicles and the warehouse facility. A dock leveller bridges the gap between the warehouse ramp and the truck or container floor. Loading/unloading is performed manually or with hand pallet trucks, powered pallet trucks, or forklifts.

- **Staging:** Staging involves preparing items or orders for further processing or shipment. A staging area is a designated space where items are temporarily held and organised before moving to the next destination. Staging improves operational efficiency, reduces errors, and facilitates smooth goods flow. It maintains order and control during warehousing processes, enhancing customer satisfaction and timely deliveries. Hand pallet trucks, powered pallet trucks and forklifts are commonly used material handling equipment in staging applications.

- **Travelling:** Powered pallet trucks and forklifts are commonly used to transport goods between the staging and storage areas within a warehouse.

- **Storage/Retrieval:** Refer to Chapter 3 for detailed information on various racking systems. Fully electric stackers, reach trucks, and articulated forklifts are commonly used to store and retrieve palletised goods from racking systems.

- **Order Picking:** Low, medium, and high-level order pickers are utilised for this operation.

- **Bulk Storage:** There are certain bulky items that can be stored in palletised form. Forklifts are commonly used equipment for this application.

Following table lists relevant MHEs for different racking types.

Racking Types (Please refer Chapter 3 for	Material Handling Equipment	Basic Capacity
Conventional Heavy Duty Racking	Stacker / Reach truck / Articulated forklift / VNA truck	1t to 2.5t
Double Deep Racking	Pantograph Reach truck with fixed mast	1.6t
Very Narrow Aisle Racking	Very Narrow Aisle Turret Truck	1t to 1.6t
Mobile Racking	Stacker / Reach Truck / Articulated Forklift	1t to 2 t
Drive-in Racking	Stacker / Reach Truck / Articulated Forklift	1t to 2 t
Shelving Racking (parts)	Order Picker	0.25t to 1.2t
Shuttle Racking	Reach Truck / Articulated Forklift	1t to 2.5t
Cantilever Racking	Multi-Directional Reach truck	2t to 2.5t

Forklift trucks operating in India must meet stringent safety, environmental, and performance standards to ensure safe and efficient operations.

Certification and Compliance Requirements

- **Mandatory Certifications:** All forklift trucks operating in India must meet BIS standards and obtain certification from ARAI to comply with CMVR regulations for Construction Equipment Vehicles (CEV).
- **Emission Norms:** Internal combustion engine (ICE)-powered forklifts, regardless of manufacturing location, must adhere to BS-CEV emission standards.
- **Import Regulations:** Imported forklifts, both IC engine and electric battery-powered, must comply with existing MHE standards. These standards apply to both new and used forklift trucks.
- **Annual Fitness Certification:** All forklift trucks in India require annual "fit-for-purpose" certification from a government agency or the original equipment manufacturer (OEM).
- **Safety Standards:** Imported forklift trucks must adhere to ISO standards for safe and efficient material handling operations.

Important Considerations: Dos and Don'ts in a Warehouse (Operational Guidelines)

Load Handling:

- Avoid moving material handling equipment (MHE) like stackers, reach trucks, or forklifts over long distances with lifted loads.
- Always lower loads when turning MHE.
- Never exceed the rated load capacity of MHE, both when lifting from the ground and at height.
- Consult OEMs for MHE suitable for handling palletised loads exceeding the rated load center.
- Fully insert forks into pallets until the load rests against the MHE carriage.
- Ensure even load distribution on pallets.

Forklift Operation:

- Always drive forklifts uphill with the load and downhill in reverse to prevent tipping. If unloaded, reverse these actions.
- Use stand-on or sit-on MHE for warehouses longer than 25 meters to improve efficiency and operator comfort.
- Standardise fork widths to 540mm or 670mm based on pallet entry sizes of 1000mm or 1200mm for junior trucks.
- Define standard aisle widths for stackers, reach trucks, and very narrow aisle (VNA) operations.
- Limit pallet overhang on racking to 75mm for safe MHE handling.
- Maintain at least 100mm safety clearance between loads and VNA trucks within the guidance system, with a maximum of 125mm for safe operation.
- Consider cameras for reach trucks handling loads above 7 meters.
- Determine appropriate travel speeds for all MHE based on internal safety requirements.

Warehouse Infrastructure:

- Define a standard clear height for warehouses after installing lights and ducts to accommodate MHE.
- Adhere to OEM guidelines for MHE maintenance, including daily checks.
- Standardise door height for MHE entry and exit based on warehouse height.
- Ensure a stable power supply for battery charging.
- Define standard ramp specifications for forklift operation with loads.

By following these guidelines, warehouses can enhance safety, efficiency, and productivity while optimize the use of material handling equipment.

05 Transportation Standards

1. Transportation modes
2. Standards and guidelines
3. Logistics network design
4. Technology and digital solutions
5. Transport safety and security

Objectives and Outcomes

Objectives:

The primary objectives of this chapter are:

- **Cost Efficiency:** Implement a standardised framework for transportation and warehousing processes that minimises operational expenses by optimize vehicle and pallet utilization.
- **Safety and Compliance:** Establish protocols ensuring the safe and compliant movement of goods through consistent adherence to regulations and industry standards for vehicle specifications and cargo handling.
- **Operational Streamlining:** Enhance logistical flow by aligning transportation and warehousing practices, ensuring smoother and faster movement of goods across distribution centres, reducing errors and delays.
- **Risk Mitigation:** Implement uniform standards to reduce risks of damage, loss, or inefficiencies during the transportation of goods, ensuring consistent product integrity.
- **Space Utilization:** Maximise space within trucks and warehouses through specific guidelines on pallet dimensions, vehicle specifications, and load management, ensuring optimum usage of resources.
- **Scalability and Flexibility:** Ensure the logistics network can scale efficiently with demand fluctuations, leveraging standardised processes that allow for quick adaptation to volume changes without sacrificing efficiency.
- **Sustainability:** Promote environmentally sustainable practices through optimization of transportation routes, reduced fuel consumption, and improved vehicle utilization, aligning with global sustainability goals.
-

Outcomes:

The intended outcomes from implementing the guidelines in this chapter are:

- **Cost Reduction:** Optimise space and resources, reducing inventory storage and transportation costs.
- **Affordability:** Standardise equipment, enabling bulk purchasing, simplified inventory, and reduced procurement and maintenance costs.
- **Operational Efficiency:** Streamline warehouse operations, reducing errors, improving productivity, and minimising delays and damages.
- **Inventory Management:** Facilitate accurate forecasting and inventory management, reducing excess stock and holding costs.
- **Enhanced Scalability:** Enable seamless scalability of operations to adapt to fluctuating demand.

By adhering to these standards, warehouses can achieve cost efficiency, operational effectiveness, and overall affordability.

Introduction

Transportation is a crucial component of warehousing operations, serving as a vital link in the supply chain. It connects various logistics network parts, facilitating the flow of goods from suppliers to warehouses and, eventually, to customers. This chapter explores key standards related to transportation within warehousing, covering topics such as transportation modes, logistics network design, vehicle dimensions and payload capacities, network optimization, turning radius considerations, maintenance, freight management, last-mile delivery, safety, security, environmental sustainability, and collaboration. The objective is to establish quality standards that enhance freight transport and logistics performance in warehousing and to drive performance improvements by defining a core set of indicators developed with stakeholder input to standardise sizes, systems, and procedures. This includes promoting more efficient and environmentally friendly transport options and enhancing overall logistics performance.

5.1 Transportation Modes

The warehousing industry utilises a variety of transportation modes, including road, rail, air, and water, depending on factors such as distance, urgency, cost, and the nature of the goods being transported. Each mode offers unique advantages and has specific limitations.
For example:

- Road transport provides flexibility and door-to-door delivery, making it ideal for shorter distances and diverse cargo.
- Rail transport, on the other hand, is efficient for long-distance bulk shipments due to its capacity and cost-effectiveness.
- Air transport is the preferred choice for time-sensitive goods, while
- Water transport is suited for large-volume goods due to its high capacity and lower costs.

Selecting the appropriate mode is crucial and should be based on the specific requirements of the warehousing operation.

5.2 Road Transport Standards and Guidelines

To ensure consistency in quality and optimise costs and efficiencies in road transport, it's crucial to adhere to established standards. Existing road transportation infrastructure standards are governed by rules such as the CMVR (Central Motor Vehicles Rules) and must be adhered to by all users of transportation infrastructure. These standards govern various aspects such as vehicle specifications, safety protocols, and operational procedures. By following these guidelines, companies can streamline their logistics operations, enhance reliability, and reduce unnecessary expenses.

Vehicle Dimensions, design and the standard pallet loading plan:

Trailer/Truck Type	Max. Wght.	Dimensions in Ft.			Dimensions in Meters				No. of Pallets		
Description	In MT	L	W	H	L	W	H	CBM	1200 x 1200	1200 x 1000	1200 x 800
Box Trailer	23.00	40.00	7.50	9.50	12.19	2.29	2.90	80.70	10	20	25
Curtain Slider Trailer	24.50	40.00	7.50	9.50	12.19	2.29	2.90	80.70	10	20	25
40' Container Trailer (Triple Axle / Double Crown)	38.00	40.00	7.50	9.50	12.19	2.29	2.90	80.70	10	20	25
40' Container Trailer Triple Axle	30.00	40.00	7.50	9.50	12.19	2.29	2.90	80.70	10	20	25
40' Container Trailer (Double Axle)	23.00	40.00	7.50	9.50	12.19	2.29	2.90	80.70	10	20	25
32' MXL Container body truck	14.00	32.00	7.50	8.00	9.75	2.29	2.44	54.37	8	17	20
32' SXL Container body truck	9.00	32.00	7.50	8.00	9.75	2.29	2.44	54.37	8	17	20
24' MXL Container body truck	14.00	24.00	7.50	8.00	7.32	2.29	2.44	40.78	6	13	15
24' SXL Container body truck	7.50	24.00	7.50	8.00	7.32	2.29	2.44	40.78	6	13	15
20' MXL Container body truck	7.00	19.50	7.00	7.50	5.94	2.13	2.29	28.99	4	8	11
Eicher 19'	7.00	18.50	7.00	7.50	5.64	2.13	2.29	27.50	4	8	11
Eicher 17'	5.00	17.00	6.00	7.00	5.18	1.83	2.13	20.22	4	5	8
Eicher 14'	4.00	14.00	6.00	6.50	4.27	1.83	1.98	15.46	3	4	6
Tata 407	2.50	9.00	5.50	5.00	2.74	1.68	1.52	7.01	2	2	4
Mahindra Bolero Pick Up	1.50	9.00	5.50	5.50	2.74	1.68	1.68	7.71	2	2	4
Tata Ace	0.85	7.00	4.80	4.80	2.13	1.46	1.46	4.57	1	2	2

Guidelines for Truck Body Standards

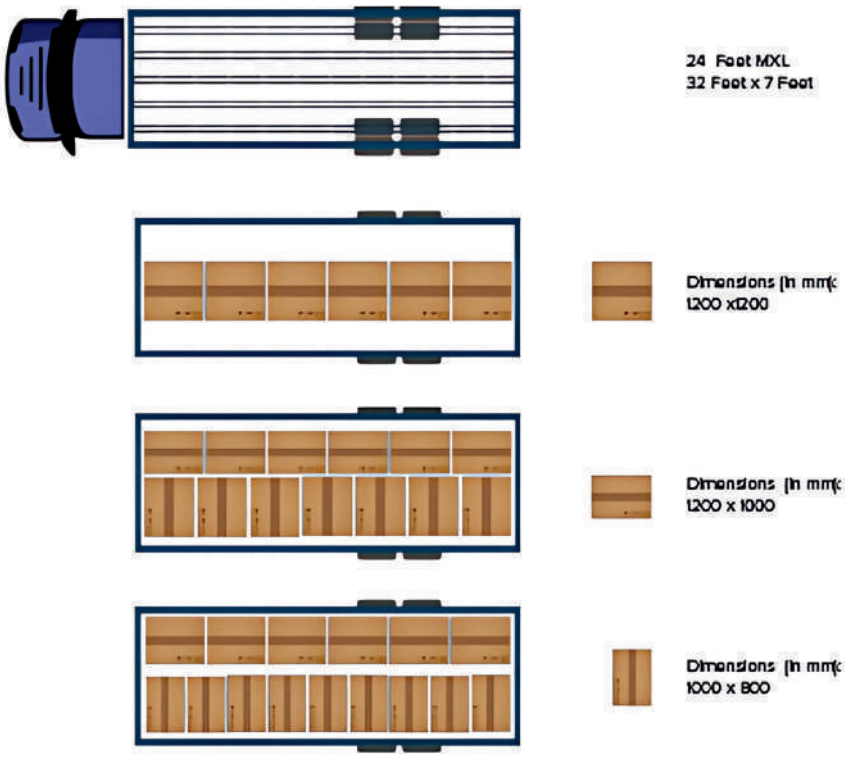
- **Internal Width Specification:** The ideal truck body must have a clear internal width of 2286 mm. This specification is essential to accommodate various pallet standards, including 1200 mm x 1200 mm, 1200 mm x 1000 mm, 1200 mm x 800 mm, and 1140 mm x 1140 mm, with an additional clearance of 50 mm on either side for optimal efficiency.

- **Loading Access Features:** The truck design should incorporate at least one side with a collapsible flap to enable side loading of pallets using forklifts. This feature is particularly crucial for facilities without ramps or dock levelers. Alternatively, the truck must permit forklifts to load and unload pallets from the rear, utilising a dock leveler for seamless container entry.

- **Regulatory Compliance:** All truck bodies must adhere to the standards and regulations outlined in the Central Motor Vehicles Rules (CMVR) and the Code of Practice for Construction and Approval of Truck Cabs, Truck Bodies, and Trailers as specified by the Ministry of Road Transport and Highways (MoRTH).

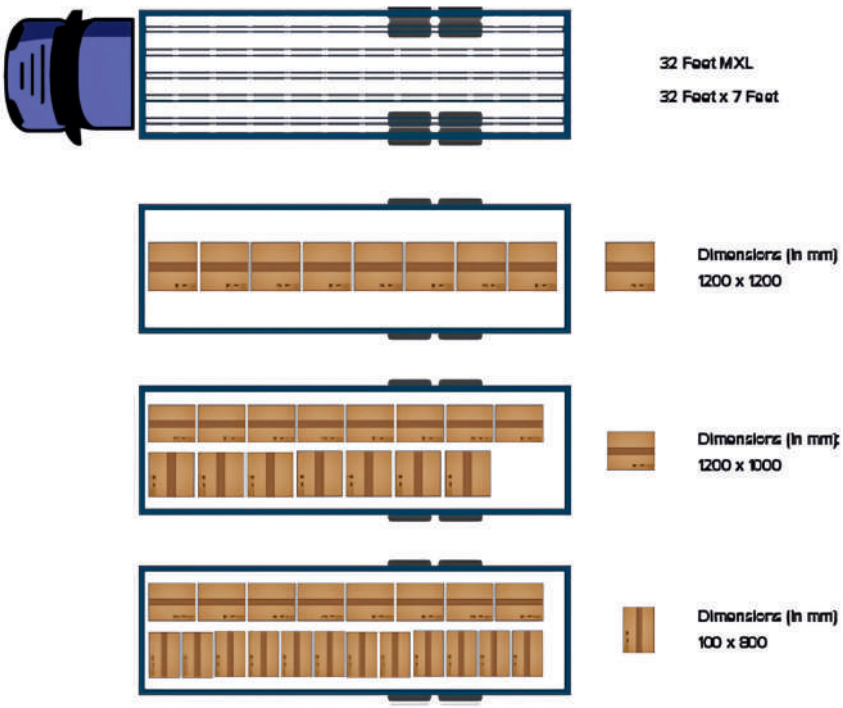
- **Flooring Requirements:** The flooring of trucks and trailers should be smooth and robust, capable of supporting the movement of Battery-Operated Pallet Terminals (BOPT) and forklifts. This specification is necessary for efficient single or double stacking of palletised loads.

24' MXL Container body truck



- Trailer/Truck Type: 24' MXL Container body truck
- Max Weight: 1400 MT
- Dimensions: 24 x 7 x 8 Feet
- No. of Pallets: 6, 13, 15

32' MXL Container body truck

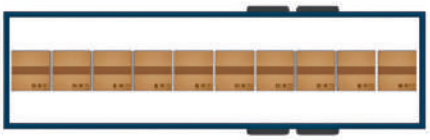


- Trailer/Truck Type: 32' MXL Container body truck
- Max Weight: 1400 MT
- Dimensions: 32 x 7 x 8 Feet
- No. of Pallets: 8, 17, 20

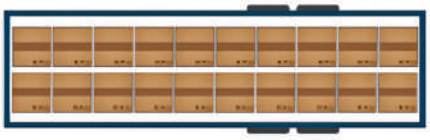
40' Container Trailer (Triple Axle / Double Crown)

40 Feet MXL

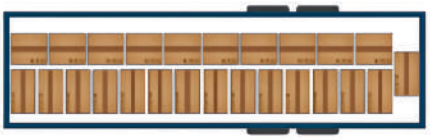
40 Feet x 7 Feet



Dimensions (in mm): 1200 x 1200



Dimensions (in mm): 1200 x 1000



Dimensions (in mm): 1000 x 800

- Trailer/Truck Type: 40' Container Trailer (Triple Axle/Double Crown)
- Max Weight: 38.00 MT
- Dimensions: 40 x 7.5 x 9.5 Feet
- No. of Pallets: 10, 20, 25

5.3 Dock Design Requirements by Vehicle Class

Efficient dock planning is critical to the operational success of any warehouse. Dock dimensions must align with the types of vehicles servicing the facility to ensure safe, swift, and seamless loading and unloading operations. In India, a wide range of vehicles—from light commercial vans to large container trailers—service warehouses, each with unique dimensional and maneuvering needs.

To support safe operations, optimize material flow, and minimize turnaround time, the Warehousing Association of India provides standardized dock height and apron space guidelines based on prevalent vehicle types. These recommendations help warehouse designers and operators ensure compatibility with vehicle fleets, minimize equipment wear, and improve throughput efficiency.

Vehicle Class	Typical Vehicle Bed Height (mm)	Recommended Dock Height (mm)	Typical Dock Width per Bay (m)	Recommended Apron Depth (m)
Light Commercial Vehicles (LCVs)	750–900	750–900	2.5–3.0	10–12
Medium Commercial Vehicles (MCVs)	1,000–1,200	1,000–1,200	3.0–3.5	12–15
Heavy Commercial Vehicles (HCVs)	1,200–1,400	1,200–1,400	3.5–4.0	15–18
Container Trailers (20'/40')	1,200–1,400	1,200–1,400	3.5–4.0	18–20
Refrigerated Trucks	1,300–1,500	1,300–1,500	3.5–4.0	15–18

5.4 Network Optimization: Logistics Network Design

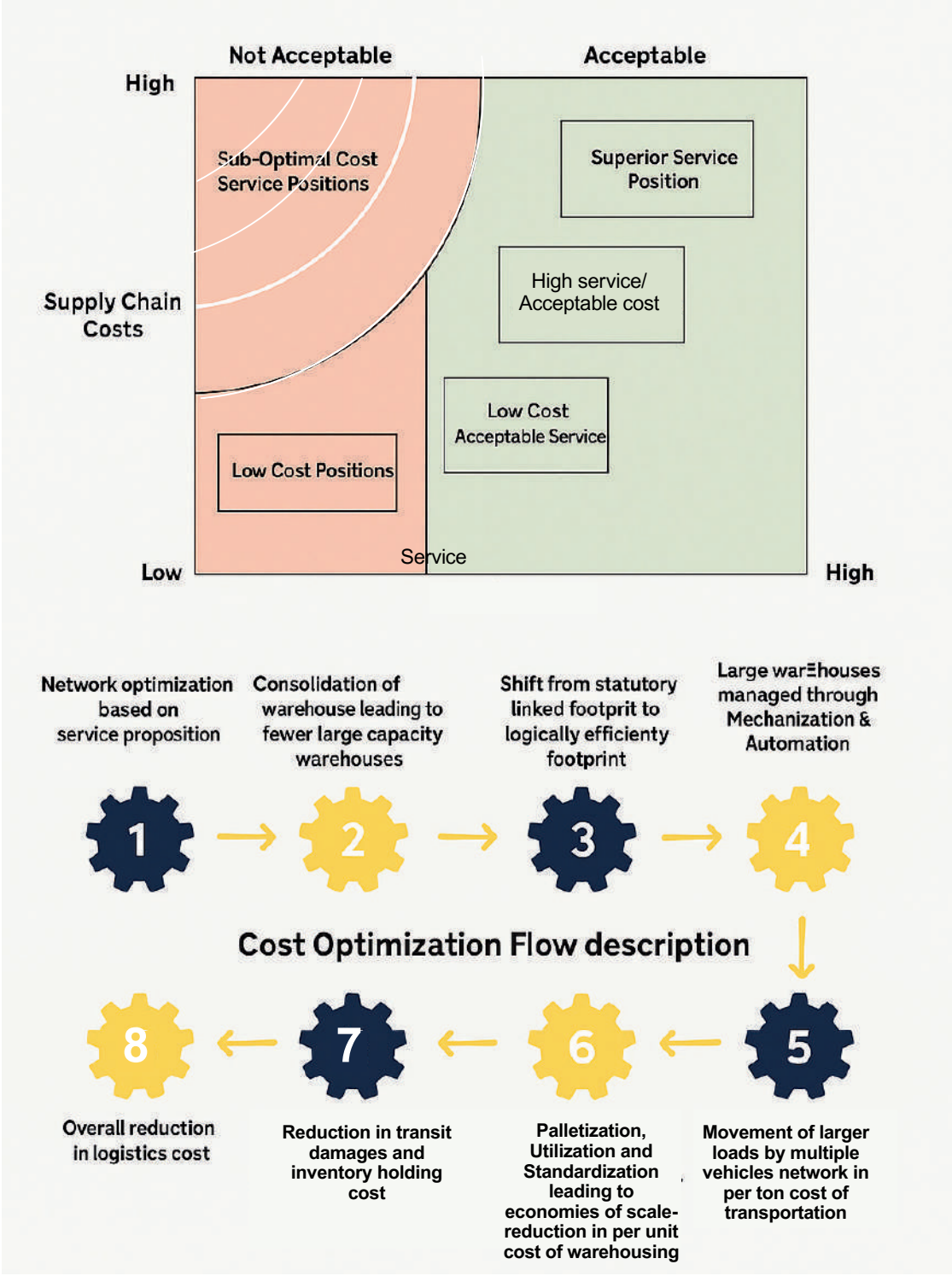
Creating an optimised logistics network is essential for effective transportation management. This process involves strategically locating warehouses and planning the most efficient transportation routes to ensure timely and cost-effective deliveries. Key considerations include customer demand patterns, warehouse locations, and the quality of transportation infrastructure. Transportation serves as the critical link that facilitates the smooth movement of goods between warehouses, thereby maintaining an efficient logistics network.

Optimizing supply chain networks can yield significant cost savings. Standardizing various aspects of the logistics industry, such as processes and protocols, is vital for achieving these efficiencies. One recommended approach is to develop and implement network design models based on delivery lead time constraints, ranging from immediate deliveries to those that may take up to 72 hours. By plotting these variations on a graph, the optimal cost can be determined, resulting in an efficient network design.

Outsourcing logistics services to professional providers is another strategy that can lead to cost reductions through shared cost options. Collaborative logistics initiatives also offer significant benefits.

Competitors can work together to serve common customers, or customers can bundle orders from competing suppliers. For instance, trucking companies can consolidate freight into a single truckload, maximizing capacity utilization and ensuring committed return loads. This strategy improves asset utilization, reduces turnaround times, and fosters a more efficient and cost-effective logistics environment.

Implementing a standardised daily checklist for all vehicles entering and leaving the warehouse not only enhances the safety and security of the vehicles and their cargo but also streamlines operations and helps optimise maintenance costs. This practice ensures that any potential issues are identified and addressed promptly, reducing the risk of accidents and delays, and maintaining the vehicles in optimal condition.



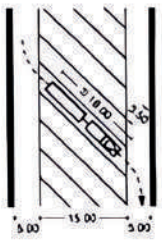
Truck Check sheet		Dates till EOM					
Truck Sr. No. (Assign Internal no. to ALL)			1	2	3	4	5
Check Points	Vehicle Details						
	Truck no.						
	Truck Registration date						
	Truck Kilometre (Odometer)						
	Supplier Name						
	OK		0	0	0	0	0
	NG		0	0	0	0	0
1	Coolant levels						
2	Wiper bottle						
3	Tire air pressure and tyre Condition						
4	Battery terminals check						
5	Check under/inside vehicle for any fluid leaks						
6	Cleanliness of truck inside container						
7	Mirror- Driver & Co-driver						
8	Seat belts available						
9	Stoppers available for tyre and back door						
10	Trolley holding belt/ Bar						
11	Brakes and accelerator pads						
12	Wipers						
13	Horn						
14	Reverse horn condition						
15	Head lights working						
16	Brake lights working						
17	Turn Signals working (Front/Rear)						
18	Wiring Condition of truck						
19	Door locks and handles (For safety)						
20	Fire extinguisher availability						
21	Basic Tool kit						
22	Tow & Tow rod						
23	Vehicle fitness certificate available						
24	Any Modification in Truck Approved						
25	Hinge condition for all doors						
26	Availability of whistle with helper						
27	Battery Maintenance - water level & life check (frequency once in a month)	Plan Actual					
	Details of any Issues						
	Countermeasure Taken						
	Implementation Date						

Vehicle Turning Radius

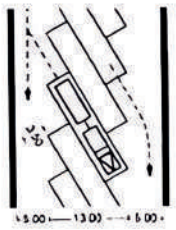
The vehicle turning radius of a truck is a crucial factor to consider during warehouse design.

- Design Considerations: Warehouse access roads, main roads, entry ramps, and the docking area should all be planned with the truck's turning radius in mind.
- Guidance: The following diagrams (not shown in the image) offer insights on how to incorporate turning radius calculations into the warehouse design process.

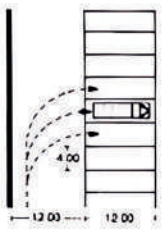
Designing for Vehicles



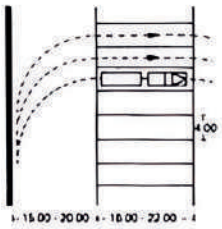
45 parking, truck with trailer



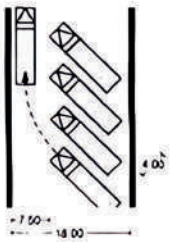
30 parking, truck with trailer



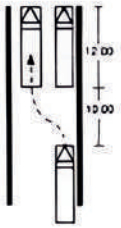
90 parking, single truck



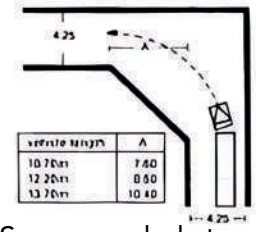
90 parking, truck with tailer



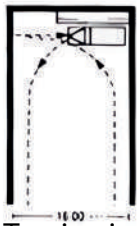
Parking at less than 45



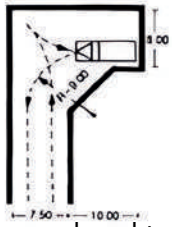
Space loss, parking parallel to kerb



Space needed at street corners

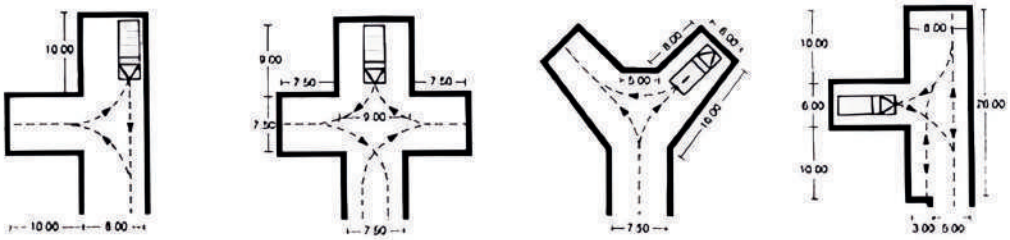


Turning in restricted areas



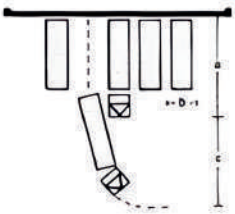
Hammerhead turn in width tight space

Passage



Further turning options

Single parking



Parking in a row

5.5 Advancements in Road Transportation Technology

The Indian Road transportation industry is undergoing a substantial transformation driven by technological advancements. A key development is the widespread adoption of telematics and GPS tracking systems that comply with AIS-140 standards. These systems enable real-time monitoring and tracking of vehicles, providing fleet operators with the ability to optimise routes, reduce fuel consumption, and enhance overall operational efficiency.

GPS tracking systems offer precise location data, facilitating efficient dispatching, route planning, and load management. Moreover, telematics solutions provide valuable insights into driver behavior, allowing fleet operators to identify unsafe driving practices and implement measures to improve road safety.

Another significant trend is the integration of fleet management systems (FMS) into operations. FMS solutions streamline various aspects of fleet management, including vehicle maintenance, fuel management, and driver performance monitoring. By leveraging data-driven insights, fleet operators can proactively schedule maintenance, monitor fuel consumption, and enhance driver productivity. This leads to reduced operational costs, minimised downtime, and improved compliance with regulatory requirements.

Additionally, the emergence of digital solutions such as mobile applications and cloud-based platforms has revolutionised the road transportation industry. These technologies facilitate seamless communication, efficient document management, and streamlined logistics coordination.
Overall, the integration of technology into the Indian road transportation sector is driving significant improvements in efficiency, safety, and operational effectiveness.

5.6 Digital Solutions Revolutionising Operational Effectiveness

Digital solutions have revolutionised the road transportation industry. Online freight marketplaces and digital freight forwarding platforms streamline the process of connecting shippers and carriers, eliminating paperwork and enabling real-time cargo tracking. These platforms offer end-to-end solutions, from booking shipments to managing documentation.

Artificial intelligence and machine learning optimise operations by predicting demand, optimize loads, and providing accurate delivery time estimates. This enhances supply chain visibility and customer satisfaction. Additionally, digital payments and electronic toll collection systems like FASTags simplify financial transactions and reduce delays, improving overall efficiency. These technological advancements are transforming the industry by optimize resources, reducing costs, and elevating customer service.

Additionally, artificial intelligence (AI) and machine learning (ML) technologies are being employed to optimise operations further. AI-based algorithms analyse historical data to predict demand patterns, enabling more accurate capacity planning and load optimization. ML algorithms are utilised to generate accurate estimates of transit times and provide proactive notifications to customers regarding potential delays or disruptions. This enhances supply chain visibility and enables proactive decision-making, thereby reducing lead times and improving overall customer satisfaction.

Furthermore, the integration of digital payment systems and electronic toll collection solutions has significantly streamlined financial transactions and reduced delays at toll plazas. The adoption of electronic toll collection systems, such as FASTags, enables seamless and cashless transactions, leading to reduced congestion and improved efficiency in the transportation network.

5.7 Last-Mile Delivery

Last-mile delivery is the final leg of transportation from the warehouse to the end customer. It faces unique challenges like urban congestion, diverse customer demands, and time-sensitive deliveries. Efficient route planning, prioritized delivery schedules, and technology for visibility and customer experience are crucial. Alternative delivery methods like drones and collaboration with local service providers can improve efficiency.

5.8 Transport Safety and Security

Transport safety and security are paramount in transportation operations. Compliance with regulatory requirements, industry standards, and best practices is essential. Safety measures like driver training programs, regular vehicle maintenance, and cargo securing techniques ensure safe transportation. Advanced technologies like GPS tracking, surveillance systems, and tamper-evident packaging enhance security.

5.9 Environmental Sustainability

Environmental sustainability is vital in warehousing operations, including transportation. Reducing the carbon footprint through fuel-efficient vehicles, alternative energy sources, and emission reduction strategies is essential. Eco-friendly transportation practices contribute to environmental stewardship and align with global sustainability goals.

5.10 Collaboration and Partnerships

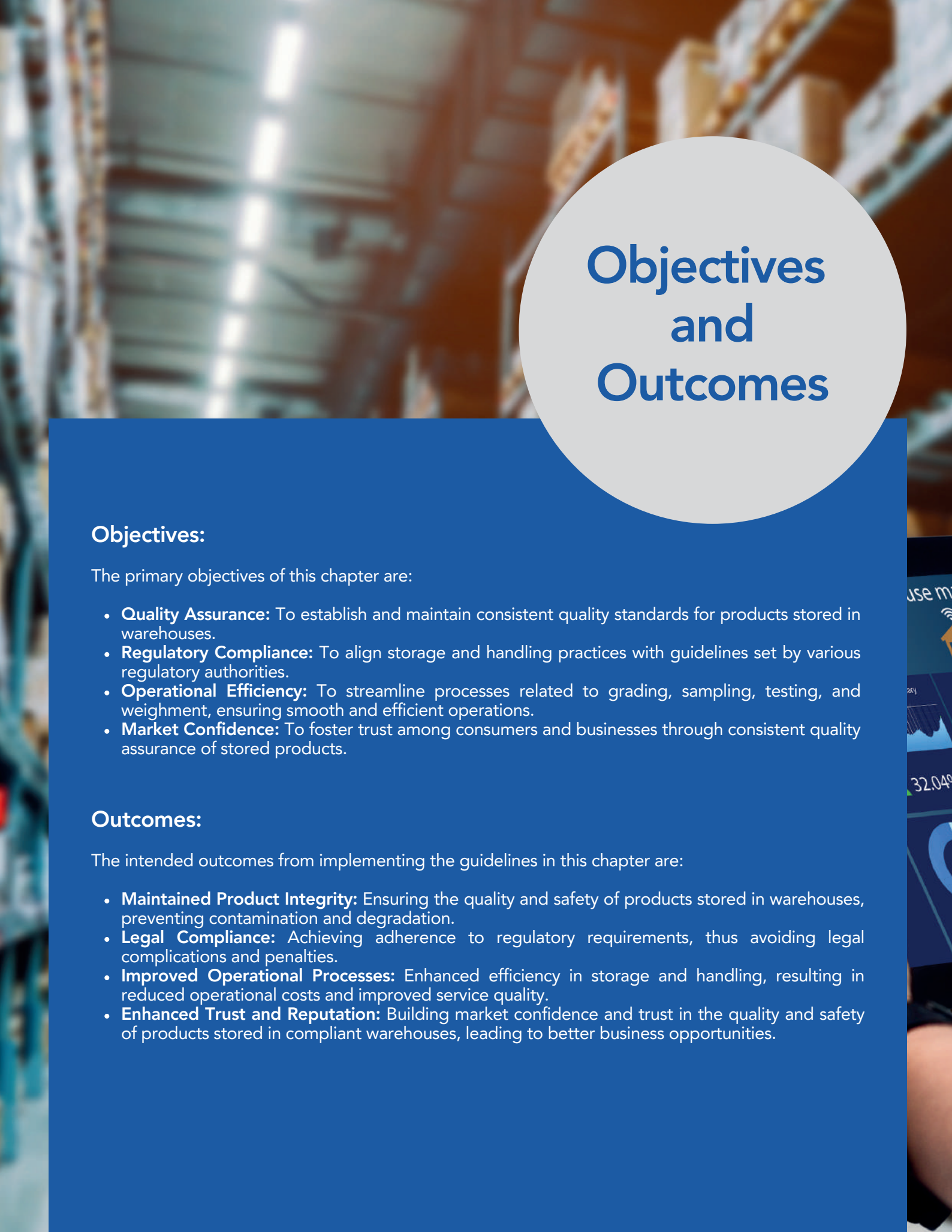
Effective transportation hinges on strong partnerships between warehousing providers, transportation companies, and other supply chain stakeholders. By sharing resources, collaborating on logistics, and aligning goals, these parties can significantly reduce costs and enhance service quality. Joint planning, shared infrastructure, and open communication are essential for rioritize transportation operations and creating a synergistic supply chain.

Transportation is an indispensable element of warehousing. Efficient and reliable movement of goods within the supply chain depends on careful consideration of transportation modes, rioritiz logistics networks, effective freight management, and robust last-mile delivery strategies. Prioritising safety, security, and environmental sustainability while fostering collaboration is crucial for achieving operational excellence and customer satisfaction.

06

Product Specific Standards

1. Assaying and grading standards
2. Sampling and testing standards
3. Weighment standards



Objectives and Outcomes

Objectives:

The primary objectives of this chapter are:

- **Quality Assurance:** To establish and maintain consistent quality standards for products stored in warehouses.
- **Regulatory Compliance:** To align storage and handling practices with guidelines set by various regulatory authorities.
- **Operational Efficiency:** To streamline processes related to grading, sampling, testing, and weighment, ensuring smooth and efficient operations.
- **Market Confidence:** To foster trust among consumers and businesses through consistent quality assurance of stored products.

Outcomes:

The intended outcomes from implementing the guidelines in this chapter are:

- **Maintained Product Integrity:** Ensuring the quality and safety of products stored in warehouses, preventing contamination and degradation.
- **Legal Compliance:** Achieving adherence to regulatory requirements, thus avoiding legal complications and penalties.
- **Improved Operational Processes:** Enhanced efficiency in storage and handling, resulting in reduced operational costs and improved service quality.
- **Enhanced Trust and Reputation:** Building market confidence and trust in the quality and safety of products stored in compliant warehouses, leading to better business opportunities.

Introduction

Products stored in warehouses can be classified as agricultural and non-agricultural products. These products should be stored in warehouses that comply with relevant standards to ensure consistent quality.

In this regard, it is essential to identify and implement standards for grading, sampling and testing and weighment of products. The guidelines for agricultural products and commodities are specified by the Warehouse Development and Regulatory Authority (WDRA).

6.1 Assaying and Grading Standards

The standards specified for grading of agricultural commodities stored in WRDA-registered warehouses are mandatory and aimed at achieving optimum quality standards for the products.

Agricultural Commodities

1. AGMARK, or Agriculture Mark, is the certification mark to assure the quality of agricultural products in India. AGMARK assures agricultural products conforming to a grade standard notified by Directorate of Marketing & Inspection (DMI), Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare under Agricultural Produce. It covers quality guidelines for more than 200 different commodities ranging from pulses to cereals, from essential oils to semi-processed food like vermicelli. AGMARK standards for most agricultural commodities assigns grades based on their intrinsic quality, cleanliness, extraneous matter, active components etc.
2. The standards for specific commodities are set by various regulatory authorities, such as the Tea Board, Rubber Board, Bureau of Indian Standards (BIS), and other product-specific agencies. These food-specific standards encompass areas such as assaying/grading, sampling and testing, and weighment

Non-Agricultural Commodities

For non-agricultural commodities, both domestic and international standards apply. Key standards include:

1. **BIS Standards** for assaying metals like brass, copper, lead etc.
2. **Global standards** for assaying prescribed by international agencies such as London Metal Exchange (LME), London Bullion Market Association (LBMA), Chicago Mercantile Exchange (CME).

6.2 Sampling and Testing Standards

The standards for testing are mandatory for WDRA registered warehouses, facilitating adherence to specified quality for the products.

- IS 2860: Sampling and testing of processed fruits and vegetables
- IS 4333 has 5 parts, all these may be referred.
- IS 4333: Part 1: Methods of analysis for foodgrains Part 1 Refractions (Third Revision)
- IS 4333: Part 2: ISO 712: Methods of analysis for foodgrains Part 2 Determination of moisture content (Second Revision)
- IS 4333: Part 3: ISO 7971-3: Methods of analysis for foodgrains Part 3 determination of bulk density called mass per hectolitre (Second Revision)
- IS 4333: Part 4: ISO 520: Methods of analysis for foodgrains Part 4 determination of the mass of 1000 grains (Second Revision)
- IS 4333: Part 5: Methods of analysis for food grains Part 5 Determination of uric acid
- IS 6261: Analysis of insects and rodent contamination in grains
- IS 8077: 'Procedure for checking temperature of quick – Frozen foods'
- IS 8184: Determination of ergot in food grains
- IS 10768: Test of quality characteristics of pulses
- IS 11396: Test for determination of storability of food grains
- IS 12529: Methods for estimation of storage losses by insects
- IS 12700: ISO 3093: 'Wheat, rye and their flours, durum wheat and durum wheat semolina –
- Determination of the falling number according to Hagberg – Perten (Second Revision)
- IS 16516: Bajra – Specification
- IS 16518: Maize – Specification
- IS 16519: Jowar – Specification
- IS 16520: Barley – Specification
- IS 16682: Ragi – Specification
- IS 16892: Sattu – Specification
- IS 3581: Green Coffee – Specification (Third Revision)
- IS 3633: Black tea – Specification (Second Revision)
- IS 15344: Green tea – Specification

Sampling of Agricultural Commodities

- IS 4115: Methods of sampling of oilseeds
- IS 4905: ISO 24153: Random sampling and rioritizedn procedures (First Revision)
- IS 14818: ISO 24333: Cereal and cereal products Sampling (First Revision)
- iv. IS 5404: Methods for drawing and handling of food samples for microbiological analysis (First Revision)

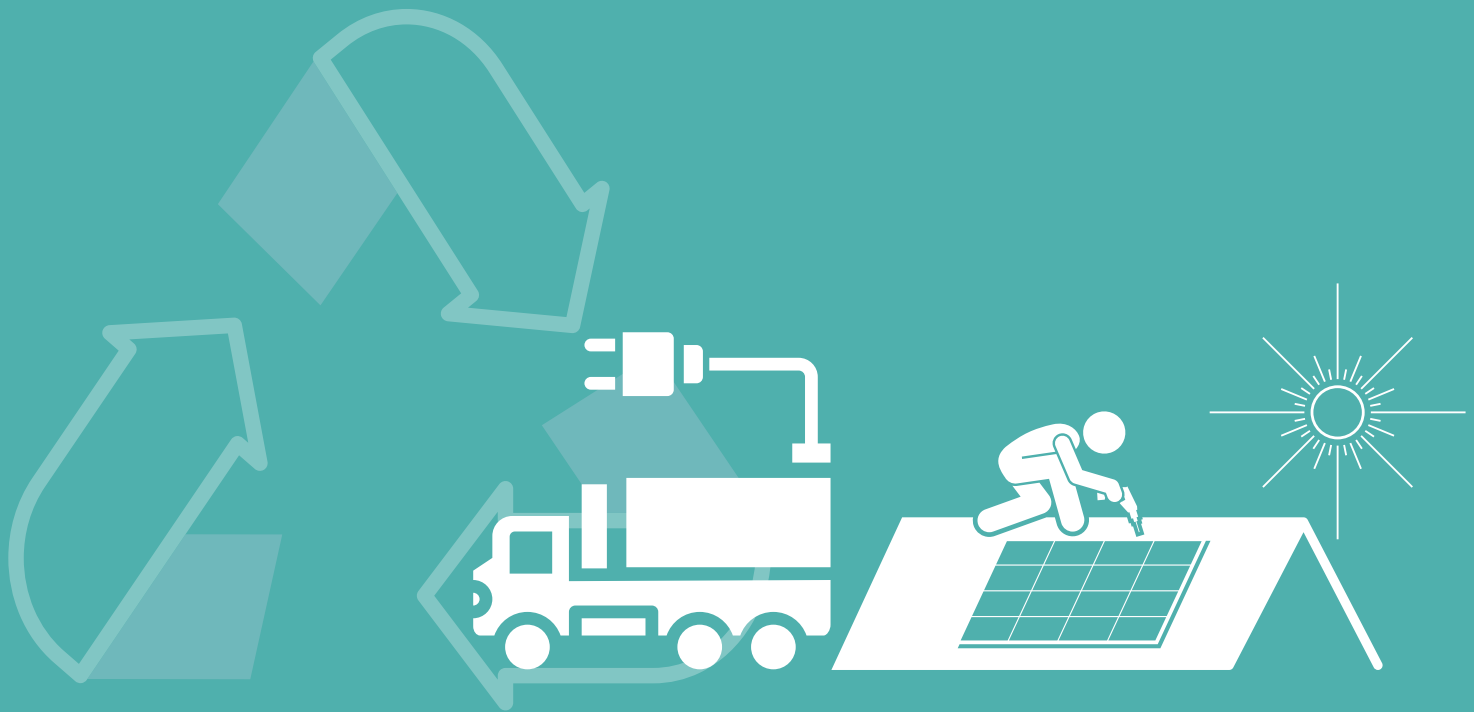
6.3 Weighment Standards

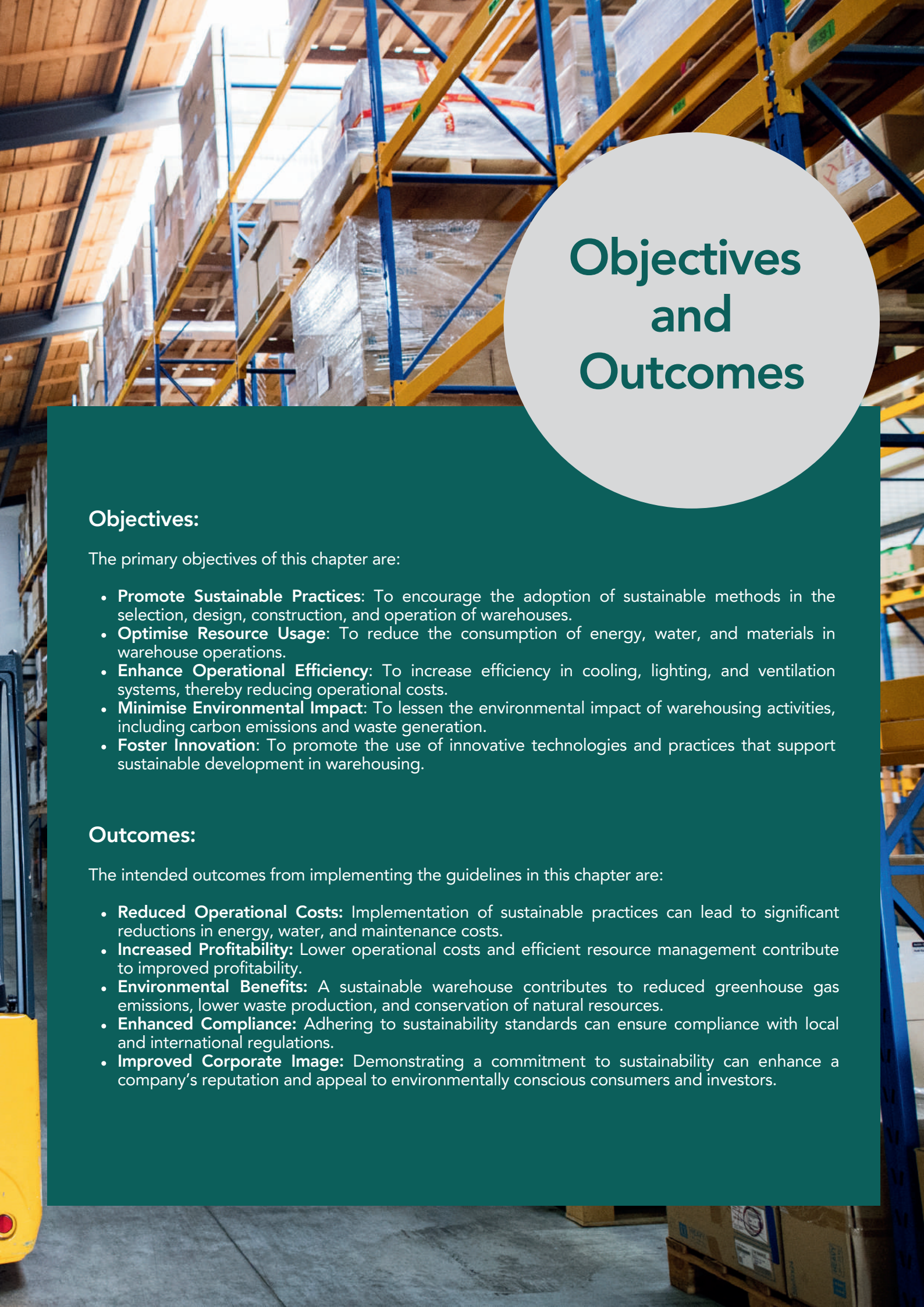
While grading and testing standards primarily govern the quality of the products stored in warehouses, the standards specified for weighment are aimed to ensure the quantity of products. The existing standards are mandatory and must be adhered to agnostic of warehouse structure.
The mandatory guidelines issued by BIS are as follows:

- BIS Standards for Weigh bridge specifications (IS 1436)
- BIS Standards for General Requirements for Weighing Instruments (IS 1432)

07 Sustainability Standards

1. Site selection and location strategy
2. Resource optimization
3. Efficient demand management
4. Sustainable sourcing





Objectives and Outcomes

Objectives:

The primary objectives of this chapter are:

- **Promote Sustainable Practices**: To encourage the adoption of sustainable methods in the selection, design, construction, and operation of warehouses.
- **Optimise Resource Usage**: To reduce the consumption of energy, water, and materials in warehouse operations.
- **Enhance Operational Efficiency**: To increase efficiency in cooling, lighting, and ventilation systems, thereby reducing operational costs.
- **Minimise Environmental Impact**: To lessen the environmental impact of warehousing activities, including carbon emissions and waste generation.
- **Foster Innovation**: To promote the use of innovative technologies and practices that support sustainable development in warehousing.

Outcomes:

The intended outcomes from implementing the guidelines in this chapter are:

- **Reduced Operational Costs:** Implementation of sustainable practices can lead to significant reductions in energy, water, and maintenance costs.
- **Increased Profitability:** Lower operational costs and efficient resource management contribute to improved profitability.
- **Environmental Benefits:** A sustainable warehouse contributes to reduced greenhouse gas emissions, lower waste production, and conservation of natural resources.
- **Enhanced Compliance:** Adhering to sustainability standards can ensure compliance with local and international regulations.
- **Improved Corporate Image:** Demonstrating a commitment to sustainability can enhance a company's reputation and appeal to environmentally conscious consumers and investors.

Introduction

Sustainability has become a critical consideration in various industries, including warehousing. This chapter outlines the principles and practices that can be employed to ensure the sustainable design, construction, and operation of warehouses. As warehouses play a vital role in the supply chain, their environmental impact must be minimize while maintaining operational efficiency. The standards and guidelines provided herein are designed to help warehouse operators and developers implement sustainable practices that reduce resource consumption, lower operational costs, and rioriti environmental footprints.

7.1 Sustainability in Warehousing

Sustainability in warehousing encompasses the site selection, design, construction, and operation of buildings in a manner that minimize the use of resources such as energy, water, and materials. The goal is to meet the needs of enclosed spaces—such as thermal comfort, lighting, and ventilation—without adversely impacting the external environment.

Reducing the use of natural resources can lower the operational expenses (opex) of a warehouse. With rising electricity and water tariffs, the costs associated with cooling, ventilation, and lighting can consume a substantial portion of the opex. Any reduction in these expenses can lead to greater profitability. If approached methodically, this reduction can be achieved without significantly increasing the capital expenses (capex). A study by the International Finance Corporation indicates that the payback period for meeting its global green building standard, EDGE, can be as short as one year.

Sustainability in warehousing can be implemented through the following stages:

1. Site Selection and Location Strategy
2. Resource Optimization
3. Efficient Demand Management
4. Sustainable Sourcing

7.1.1 Site Selection and Location Strategy

An appropriately located warehouse can reduce infrastructure and transportation costs and rioriti the environmental footprint. Site selection should consider the following factors:

- Accessibility to infrastructure and resources, such as roads, energy supply, and water supply
- Proximity to highways and transportation hubs (airports, seaports, railway stations, etc.)
- Distance from suppliers and expected end-users
- Potential disruption to existing natural or social systems on the site

For e-commerce, food delivery, and third-party logistics (3PL) warehouses where most orders are concentrated within a geographic region, a "Hub and Spoke" distribution model can provide efficiencies at the distribution center (hub) and reduce last-mile delivery times. This model can lower transportation costs and carbon emissions for many businesses.

7.1.2 Resource Optimization

Resource demand, such as energy and water, can be reduced by using naturally available means for cooling, ventilation, and lighting. Other methods include avoiding leakage, preventing the oversizing of systems, and ensuring systems are not in use when unnecessary.

Cooling

- Minimise windows on the east and west sides to reduce excessive heat buildup.
- Maintain overall window-to-wall ratio below 10%.
- Use window glass with a maximum Solar Heat Gain Coefficient (SHGC) of 0.5.
- Reduce skylights, when used, to less than 5% of the roof area. The maximum U-factor of the skylight should be 4.25, and the maximum SHGC should be 0.35, as per the Energy Conservation Building Code 2017.
- Prevent cooled air from escaping in temperature-controlled warehouses with entrance vestibules, air locks, or air curtains. High-speed auto-closing doors should also be considered. Exhaust fans should be fitted with a sealing device such as a self-closing damper and operable fenestration should be constructed to eliminate air leakages from fenestration frame and shutter frame. The building envelope should be sealed, caulked, gasketed, or weather-stripped at all joints, penetrations, and other openings, such as:

    i. Joints around fenestration, skylights, and door frames
    ii. Between walls and foundations, walls and roof, and wall panels
    iii. Around penetrations of utility services through roofs, walls, and floors
    iv. Between site-built fenestration and doors
    v. Building assemblies used as ducts or plenums
    vi. All other openings in the building envelope

- Thermostat setpoints and zoning should be tailored to the specific goods stored and the occupants. Different temperature zones within the warehouse should be separated by insulated walls and airtight openings. Air conditioning for human occupants should be set to 24-26 degrees Celsius.
- Manage cooling demand to variations due to occupancy or operational processes by installing cooling controls. Cooling systems should not be designed for extreme peak conditions to avoid oversizing, which can lead to increased capital costs and reduced efficiency.
- Insulation of Envelope: Insulation in roofs should have a maximum U-factor of 0.33 $W/m^2 \cdot K$, and wall assemblies should have a maximum U-factor of 0.40 $W/m^2 \cdot K$. Roof and wall areas not covered by solar panels or other systems should use solar reflectance paint with an SRI of at least 80.
- Outdoor air economisers – part of a building's cooling system that uses cool outdoor air to cool the building instead of operating the air conditioning compressor – should be considered if typical outdoor temperatures are suitable for the HVAC system design. Night-time flushing can be rioriti to cool indoor spaces when night-time outdoor temperatures are lower than desired indoor temperatures.

Lighting

- Use high windows, north-facing clerestory windows, and skylights to achieve daylighting.
- Automated daylighting controls using photoelectric sensors can regulate electric lights when natural light is sufficient.
- Occupancy controls can reduce electric lighting use during periods of unoccupancy. Timer-controlled switches can be used for external lights and entrance areas.
- Avoid oversizing systems by calculating the required lighting levels in electrical design.

Ventilation

- Ventilation rates should comply with relevant regulations and consider the space's expected function. ASHRAE 62.1-2007 standards suggest ventilation rates between 6 and 30 air changes per hour (ACH). Oversizing can increase energy consumption.
- Air dampers should be shut off automatically during unoccupied periods.

Construction Materials

- Reinforced cement concrete (RCC) slabs should be designed according to expected loads to avoid oversizing, which can increase the use of high-embodied energy materials like cement and steel.

Water

- Use local plants and trees in landscaped areas to reduce irrigation needs.

7.1.3 Efficient Demand Management

Once resource utilization is optimized, warehouse energy demand can be met by selecting efficient systems for cooling, lighting, ventilation, materials, and water.

Cooling

- **High-efficiency cooling systems** such as water-cooled chillers, heat pumps, and Variable Refrigerant Flow (VRF) systems should be considered. Low-energy cooling systems like evaporative cooling, desiccant cooling, solar air conditioning, tri-generation, radiant cooling, ground source heat pumps, and adiabatic cooling systems can also be evaluated.
- **Ceiling fans** can enhance cooling in occupied spaces, especially in locations with moderate temperatures and high humidity. High-volume low-speed (HVLS) fans can rioriti temperatures in large spaces. Variable Frequency Drives (VFDs) should be used for motors above 7.5 hp to allow operation at less than full load, resulting in significant energy savings.
- **Variable Frequency Drives (VFDs):** Building systems are typically designed to handle peak loads, which occur only 1%-5% of the time throughout the year. VFDs enable motors to operate at partial loads, significantly reducing energy consumption. It is recommended that all electric motors used in air handlers, water pumps, cooling towers, and chillers with capacities above 7.5 horsepower be equipped with VFDs to enhance energy efficiency.

Lighting

- LED lamps with a luminous efficacy of at least 90 lumens/watt should be used. The maximum lighting power density (LPD) should not exceed 7.08 W/m^2.

Ventilation

- Heat recovery systems should be installed to condition fresh air using the exhaust air's coolness. Stand-alone heat recovery ventilators or cooling systems with built-in heat recovery are recommended for air-conditioned warehouses.

Construction Materials

- Low-carbon materials like autoclaved aerated concrete (AAC) blocks, fly ash cement, and finished concrete flooring should be selected. The EDGE online software (www.edgebuildings.com) can be used to evaluate the overall embodied energy of the building.

Water

- Install low-flow fixtures, such as dual-flush toilets (maximum 6/4 liters per flush), showerheads (maximum 6 liters/minute), and faucets (maximum 6 liters/minute).
- Efficient irrigation systems, such as drip irrigation or sprinklers using less than 4 liters of water per square meter of landscaping per day, should be installed.

7.1.4 Sustainable Sourcing

Sustainable sourcing should be considered for optimizing resource utilizing and meeting warehouse energy demand by selecting efficient equipment and materials.

Energy

- Onsite solar photovoltaic panels should cover at least 25% of the roof area to benefit from low-cost energy generation and resilience against power cuts. Net metering with the local utility company should be considered where possible.

Construction Materials

- Recycling existing material reduces the use, and therefore embodied energy, of new materials yielding cost savings. Reuse existing materials, such as broken concrete for aggregate, aluminum, steel, and timber, whenever feasible. Recycled materials from demolished buildings or retrofits should be prioritized.

Water

- At least 50% of rainwater collected from the roof should be stored and reused for suitable purposes. Excess water can be directed to the aquifer through percolation ponds or wells.
- Warehouses with at least five bathrooms should install an onsite sewage treatment plant. The treated water should be used for appropriate purposes, and excess water can also be directed to the aquifer.

To maintain efficiencies, it is essential to:

- Conduct annual audits of sustainability practices and identify potential improvements.
- Monitor actual performance on energy, water, and other relevant metrics. Standard Warehouse Energy Management Systems can be used.
- Involve employees in sustainability initiatives, introduce the measures, their benefits, and operational procedures, and invite them to propose further improvements.

7.1.5 Renewable Energy Integration and Charging Infrastructure

As the logistics sector works toward decarbonisation, warehouse infrastructure must transition from being passive energy consumers to active contributors in clean energy ecosystems. Two of the most impactful interventions in this regard are the deployment of rooftop solar energy systems and the adoption of electric mobility solutions within warehouse operations.

These interventions not only reduce greenhouse gas emissions but also offer long-term cost savings, regulatory compliance benefits, and alignment with national and corporate ESG targets. However, their implementation—especially in brownfield facilities—requires careful infrastructure planning and adherence to technical standards.

The following sections detail how rooftop solar and electric mobility infrastructure can be integrated into both new and existing warehouse developments.

Rooftop Solar Applications

Rooftop solar presents a high-impact, scalable opportunity to transition warehouses toward renewable energy. Warehouses, with their expansive roof areas and high daytime energy usage, are ideal candidates for solar photovoltaic (PV) installations. Solar energy can significantly reduce grid dependency, lower energy costs, and contribute to a facility's green building credentials.

However, retrofitting solar systems in brownfield or older warehouses presents engineering challenges—especially related to roof load capacity, anchoring methods, and system safety. Hence, feasibility assessments and standards-based implementation are essential for long-term reliability and safety.

Deploying **solar photovoltaic (PV) systems** is one of the most effective ways to reduce warehouse operational carbon emissions and electricity costs. However, successful solar adoption depends on structural readiness, especially in brownfield or legacy facilities.

Key Considerations:

- Structural Assessment: Retrofitting rooftop solar on existing warehouses requires structural integrity checks. As per *IS 875 Part 1 & 2*, the dead and live loads—including solar panel weight (typically 15–20 kg/m²)—must be factored into the design.
- Roofing Systems: Standing seam roofs with solar clips or rail-free systems are preferred for leak-proof integration. Roof safety features like lifeline systems and cage ladders must be incorporated for maintenance access.
- Solar Reflectance and Heat Management: When solar is not feasible across the entire roof, high SRI coatings (≥80) should be used to reduce heat load.

Standards & Guidelines:

- MNRE Rooftop Solar Guidelines (2022)
- IS 14286 and IEC 61215: Requirements for PV modules
- IEC 62446: Testing and commissioning for grid-connected systems
- Comply with DISCOM metering protocols for net or gross metering agreements

Operational Models:

- CAPEX Model: Asset owned by the warehouse operator
- RESCO Model: Power Purchase Agreement (PPA) with a third-party solar service provider

Electric MHE and EV Charging Infrastructure

As more warehouses adopt electric material handling equipment (MHE) such as forklifts, reach trucks, and pallet jacks—as well as electric fleets for last-mile or intra-park logistics—the demand for reliable and well-designed EV charging infrastructure is growing rapidly. Electrification reduces operational emissions, enhances indoor air quality, and aligns with emerging sustainability mandates in industrial logistics.

Effective integration of EV charging in warehouse design involves more than just adding chargers—it requires load planning, safety considerations, space allocation, and compliance with power distribution norms. Proactive planning is especially important in brownfield upgrades, where electrical capacity and spatial constraints may limit retrofitting potential.

Charging Infrastructure Planning

- Load Assessment: Additional power demand should be assessed based on vehicle type, battery size, and charging frequency.
- Power Supply Design: Buildings should be equipped with 1.00–1.25 kVA per 1,000 sq. ft., allowing additional provisioning for EV charging bays.
- Charger Types:
  - *Level 1/2 AC chargers* for MHE and small vehicles
  - *DC fast chargers* for commercial electric cargo vehicles
- Location & Safety:
  - Charging bays must be located in well-ventilated, designated areas
  - Fire safety systems, cable management, and emergency shutoffs are critical

Relevant Standards:

- *IS 17017*: Electric vehicle supply equipment (EVSE) standards
- *CEA Guidelines* for charging infrastructure
- *MoHUA Model Building Bye-laws (2016)*: Recommends 20% parking space to be EV-ready

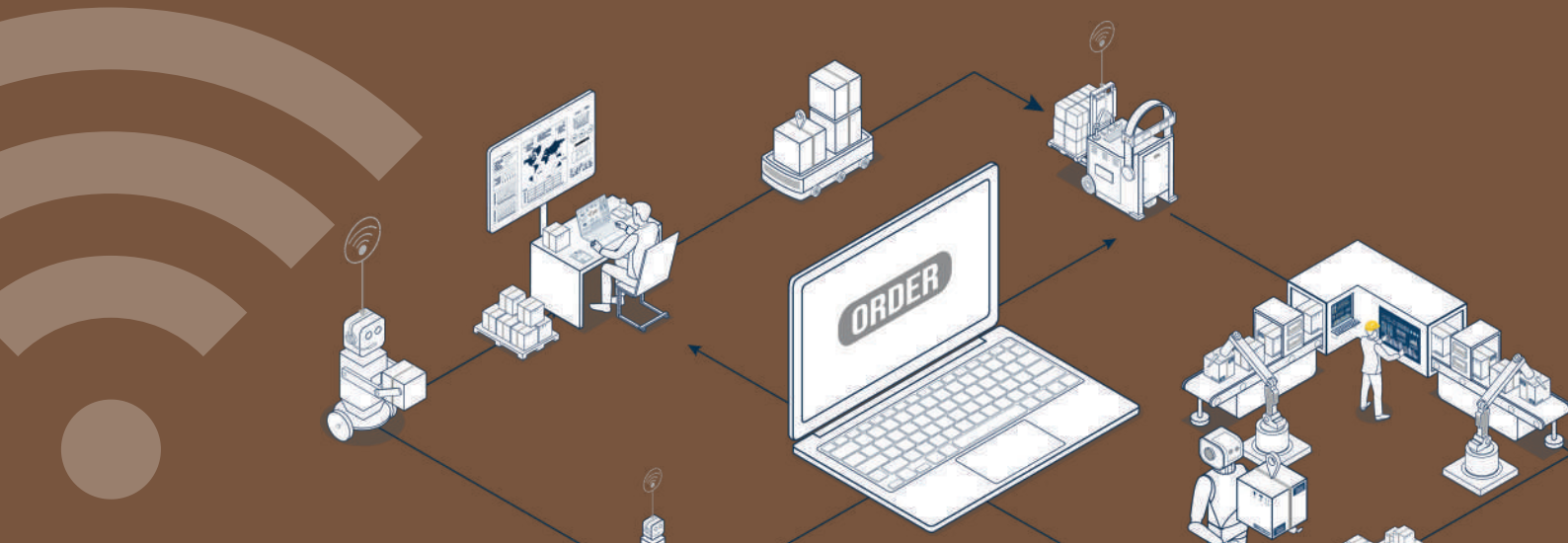
Net Impact

Integrating rooftop solar and EV charging infrastructure not only reduces operational costs and emissions but also improves a facility's eligibility for green building certifications like IGBC and EDGE. These investments also align with India's national sustainability and logistics decarbonisation goals.

08

Warehousing Technologies & Applications

1. Warehouse automation
2. AI and Vision-based applications
3. Packaging, sustainability, and waste reduction
4. Warehouse digital twin and real-time data applications
5. Warehouse management systems
6. Applicable standards



Objectives and Outcomes

Objectives:

The primary objectives of this chapter are:

- **Enhance Operational Efficiency and Accuracy:** Deploy automation and AI to streamline workflows, reduce errors, and improve output quality.
- **Optimise Resource Utilization:** Maximise use of human and material resources through intelligent systems.
- **Improve Safety and Compliance:** Introduce vision and sensor-based systems to ensure workplace safety and regulatory adherence.
- **Facilitate Data-Driven Decision Making:** Implement real-time data systems for performance visibility and strategic planning.
- **Achieve Sustainability and ESG Goals:** Use AI for packaging optimization and waste reduction to support green warehousing initiatives.
- **Enable Scalability and Flexibility:** Leverage modular technologies that adapt to changing business volumes and layouts.

Outcomes:

The intended outcomes from implementing the guidelines in this chapter are:

- **Higher Throughput and Service Quality:** Improve processing speed and accuracy to meet dynamic customer demands.
- **Reduced Operational Costs:** Lower labour and waste-related costs through automation and efficiency.
- **Real-Time Visibility and Control:** Achieve end-to-end process transparency through integrated systems.
- **Improved Safety Records:** Minimise incidents and enforce safety protocols using intelligent monitoring systems.
- **Compliance with Standards and Regulations:** Ensure alignment with local and international warehousing norms.
- **Enhanced Worker Experience:** Use ergonomically supportive technologies like wearables and voice-picking to reduce strain and training times.

Introduction

Warehousing operations are at the heart of modern supply chains, and the integration of advanced technologies is transforming traditional facilities into intelligent, efficient, and scalable logistics hubs. With increasing customer expectations and supply chain complexity, the adoption of automation, AI, robotics, and sustainable systems has become essential for warehousing success. This chapter explores a comprehensive set of technologies, their applications in warehouse settings, and their alignment with operational excellence and regulatory standards. This chapter explores key technologies shaping modern warehouses, grouped into four core themes:

- Systems and Operations Optimization
- Connected Infrastructure
- Automation Solutions
- Emerging Technologies

8.1 Warehouse Systems and Optimization

The backbone of any efficient warehouse lies in how intelligently its operations are planned, executed, and monitored. As warehousing transitions from manual, paper-based environments to digitally orchestrated ecosystems, operational systems like WMS, WES, and digital twins form the control layer that enables this transformation. These systems not only automate workflows but also optimise space utilization, improve inventory accuracy, and enable real-time decision-making.

Strategic implementation of these technologies allows warehouses to:

- Adapt quickly to demand fluctuations
- Minimise delays and bottlenecks
- Improve labour and equipment utilization
- Enhance visibility and traceability across the supply chain

This section explores the core systems that enable operational excellence and serve as the foundation for scalable warehouse automation.

8.1.1 Warehouse Management Systems

With globalization, dynamic markets, and evolving consumer behavior, Warehouse Management Systems (WMS) must integrate with external systems to ensure accurate data communication and effective business collaboration. The integration of these systems can be complex, especially when businesses operate across different industry verticals and platforms. Therefore, logistics service providers must standardize their WMS implementations with integrated solutions.
Key aspects of WMS include:

- Training & Deployment
- Project Management

- Business Requirements
- Configuration
- Integration and Testing

A WMS should be deployed after thoroughly evaluating its functionalities and relevance to the warehouse's specific processes and workflows. It should generate comprehensive reports and performance dashboards, providing insights into productivity, efficiency, task status, and time management.

Warehouse Management Systems Scope

A WMS should encompass:
- Fresh receipt and return of goods
- Storage management
- Sampling, inspection, and grading
- Picking, checking, and packing
- Goods dispatch
- Integration with Transportation Management Systems (TMS)
- Inventory counting and reconciliation
- Inventory management and client visibility
- Seamless integration of shipment notices, dispatch notes, outbound orders, alerts, and notifications
- Integration with Warehouse Control Systems (WCS) for equipment like sorters, diverters, ASRS, pallet shuttles, and robotics

Regulatory Compliance

To ensure compliance with regulatory authorities, warehouses must:
- Obtain accreditation from an accreditation agency
- Register the warehouse
- Control documents and records
- Implement correction/action processes
- Conduct internal audits and performance reviews
- Settle disputes

Labour Management Systems:

Effective labour management should include:
- Maintaining records of warehouse manpower
- Complying with labour laws and regulations
- Educating workers on their roles and responsibilities
- Providing ongoing training and skill development
- Assessing workers' performance and training effectiveness
- Establishing worker safety management systems and promoting a safety culture

Digitalisation / Digital Management Systems

Digital management systems enable robust processes for data collection and verification. They facilitate full-chain standardization, enhancing operational transparency, centralised communication, and collaboration. This comprehensive visibility allows for tracking material movement throughout the supply chain.

8.1.2 Warehouse Digital Twin and Real-Time Data Applications

Digital twins allow companies to virtually design, simulate, and test warehouse operations and product movements. This technology enables businesses to plan and optimise new sites or adjust existing facilities without physical modifications. Digital twins use real-time IoT data to create virtual replicas of the warehouse. These replicas are used to monitor operations, test layout changes, and simulate workflow scenarios.

Applications:

- Layout optimization
- Traffic and congestion heatmapping
- Predictive maintenance scheduling
- Energy usage monitoring and load balancing

Environmental Monitoring

IoT sensors track temperature, humidity, and air quality across zones. Integration with WMS and BMS triggers alerts for threshold violations and logs data for audit.

- Use Case: A pharma warehouse detected temperature excursions using real-time alerts and prevented product spoilage across cold storage zones.

Edge Computing

Edge devices process data locally, minimizing latency for applications like safety shutdowns, real-time routing, and visual recognition.

- *Use Case*: In a high-traffic zone, edge processors on AMRs enabled dynamic rerouting within milliseconds, avoiding collisions without reliance on cloud latency.

Wearables and Voice-Directed Systems

- **Voice Picking:** Operators receive verbal instructions through headsets, allowing hands-free picking and higher accuracy.
- **AR Glasses:** Display SKU details, picking locations, and alerts directly in the user's view.
- **Smart Gloves/Scanners:** Reduce motion repetition and enable rapid barcode scanning.
  - Use Case: A retail warehouse accelerated training cycles by 60% and improved productivity by 20% using wearables for zone picking.

Real-Time Visibility for Decision Making: Operational and strategic teams require accurate, up-to-date information to make informed decisions. Real-time visibility offers actionable insights that can quickly adapt plans, enhance processes, minimize risks, and capitalize on opportunities. This includes managing transit delays, monitoring weather and material conditions, rerouting based on traffic, and adjusting supply during demand fluctuations.

- **For Manufacturers:** Real-time visibility provides valuable insights into production volumes, manufacturing inefficiencies, and raw material procurement.
- **For Suppliers:** It offers key information on order backlogs, aiding in inventory management strategies.
- **For Logistics Vendors:** Real-time data on cargo batches, consignments, and delivery status helps manage daily operations and track goods efficiently.
- **For End Consumers:** It keeps them informed throughout the cycle, providing updates on dispatch and delivery status.

8.2 Connected Infrastructure

As warehouses scale in size, complexity, and throughput expectations, merely automating discrete tasks is no longer sufficient. To truly realise the benefits of digitalisation and data-driven decision-making, warehouse environments must be underpinned by connected infrastructure—a system of integrated technologies that enables seamless communication between people, machines, materials, and systems.

At the heart of this infrastructure lies the Internet of Things (IoT): a network of interconnected sensors, devices, and control systems that collect, transmit, and process real-time data from across the facility. This connectivity not only improves operational awareness and agility but also supports predictive maintenance, dynamic safety interventions, traceability, and energy optimization.

Such connectivity is essential to:

- Enable machine-to-system interoperability, where forklifts, conveyors, and robotics interact with WMS/WES platforms.
- Establish traceable material flow, using RFID, barcodes, or QR systems integrated with inventory databases.
- Promote worker and asset safety, through smart zones, geofencing, and emergency alert systems.
- Support data capture for compliance, sustainability tracking, and continuous improvement.

The following sections describe the key building blocks of connected infrastructure and how they function within modern warehouses.

8.2.1 IoT and Sensor Integration

These are foundational to a connected warehouse, enabling constant monitoring of environmental and operational parameters.

Use Cases:

- Ambient monitoring (temperature, humidity, gas levels) for compliance in cold chains and chemical storage
- Load sensors embedded in racks or pallets to track material status in real time
- Shock and vibration detection during goods movement for fragile or high-value items

Relevant Standards:

- ISO/IEC 30141: IoT Reference Architecture
- ISO 20922: MQTT Protocol – widely used for lightweight data exchange in warehouse IoT environments.

8.2.2 Connected Material Handling Equipment (MHE)

MHE like forklifts, reach trucks, and AMRs generate valuable telemetry data, which—when connected—can be leveraged for smarter routing, usage tracking, and predictive servicing.

Use Cases:

- Monitoring forklift battery levels and movement patterns to reduce idle time
- Real-time MHE location sharing with dock scheduling or WMS platforms
- Onboard diagnostics to reduce unplanned maintenance and improve equipment lifecycle

Standards:

- *ISO 3691-1*: Safety of industrial trucks
- *IEC 61508*: Functional safety of electrical/electronic systems used in industrial automation.

8.2.3 RFID and QR-Based Applications

These technologies form the digital identity layer for assets, inventory, and packaging materials, enabling fast, non-line-of-sight data capture.

Use Cases:

- Automated goods receipt and dispatch validation via RFID gates
- Rapid inventory counting and discrepancy checks using handheld scanners
- Track-and-trace systems for serialized products and high-value items

Standards:

- ISO/IEC 18000 Series: RFID standards by frequency band and protocol
- GS1 EPCglobal: Serialization and traceability standards adopted across global supply chains

8.2.4 Smart Worker Safety and Monitoring Systems

Connected safety solutions proactively mitigate risks in dynamic warehouse environments where humans and machines operate side-by-side.

Use Cases:

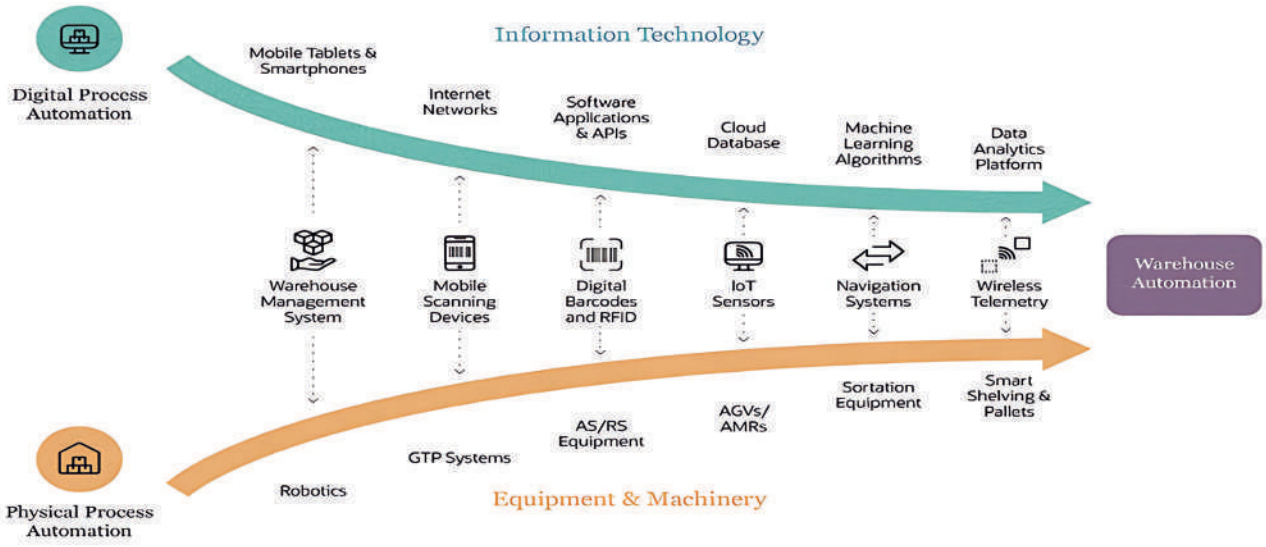
- Wearables that monitor worker location, fatigue, or fall events
- Proximity sensors and geofencing to prevent MHE collisions
- Vision-based PPE compliance checks at zone entry points

Standards:

- ISO 45001: Occupational Health and Safety Management Systems
- IEC 61496: Electro-sensitive protective equipment
- TAPA FSR (Facility Security Requirements): Guidelines for physical and operational warehouse security

8.3 Warehouse Automation

Automation reduces time, effort, and cost while minimising errors and increasing productivity. It results in higher efficiency, better service quality, and improved safety. Warehouse automation is the process of automating the movement of inventory into, within, and out of warehouses to customers with minimal human assistance. It typically involves a combination of digital process automation and physical process automation.



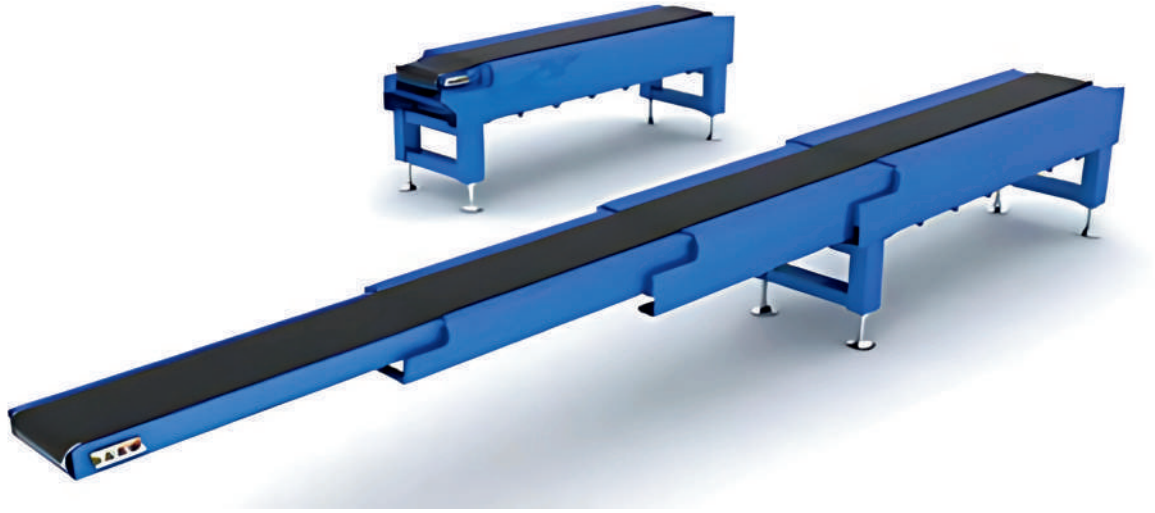
Warehouse automation ensures that business-critical operations in the warehouse meet customer demand. It begins with a Warehouse Management System (WMS), which automates manual processes and data capture, and supports inventory control and data analysis. These systems integrate with other solutions to efficiently manage and automate tasks across different business and supply chain functions.

Although warehouse automation projects can be expensive, they offer a fast return on investment. The impressive ROI is due to multiple savings points provided by automation, including reduced labour costs, higher performance, optimised handling and storage costs, minimised inventory errors, and eliminated risks of mishandling and product loss.

Following sections present some automation solutions for **Loading/Unloading, Picking, Sortation, Movement, and Storage and Retrieval** within the warehouse. A table at the end of the chapter lists various technologies, equipment, their applications, and national and international manufacturers.

8.3.1 Loading/Unloading

- **Telescopic Conveyor:** When loading and unloading trucks, an extendable conveyor makes a significant difference. This solution extends from the permanent conveyor to the nose of the truck trailer, making cargo handling faster, easier, and safer. Available in various lengths, widths, and with different accessory options, the telescopic belt conveyor can fill a container without an operator, making it suitable for top warehouse automation companies or distribution centre applications handling smaller packages.



- **Powered Flex Conveyor:** The Powered Flex Conveyor has a robust design that provides optimal conveying power and can be easily moved to where it's needed most. The flexible, expandable conveyor stretches or bends to fit the available space, making it ideal for truck loading and unloading areas.

8.3.2. Picking

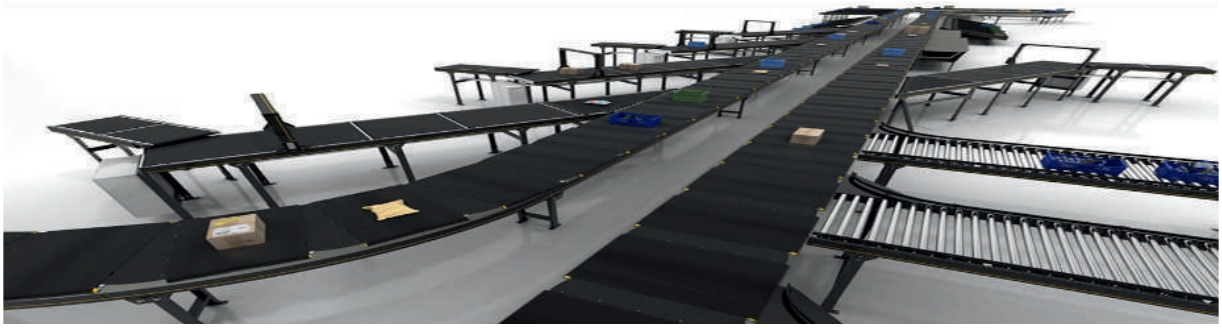
- **Put To Light:** Put-to-Light systems are an effective automated sortation method for breaking larger quantities of product into individual customer orders. Using light devices, these systems direct operations to "put" items into the correct orders. Sometimes referred to as "scan and sort," products are typically batch-picked beforehand and brought to a put station. Operators scan bar codes on individual products, and lights indicate which customer orders require that product.

- **Pick To Light:** Pick-to-Light is a light-directed order fulfilment technology that provides an accurate, simple, and efficient method for paperless picking, putting, sorting, and assembling products. This system also helps lower labour costs. It typically uses different coloured LED lights along with letters and numbers. These components facilitate faster product accumulation while maintaining inventory accuracy.

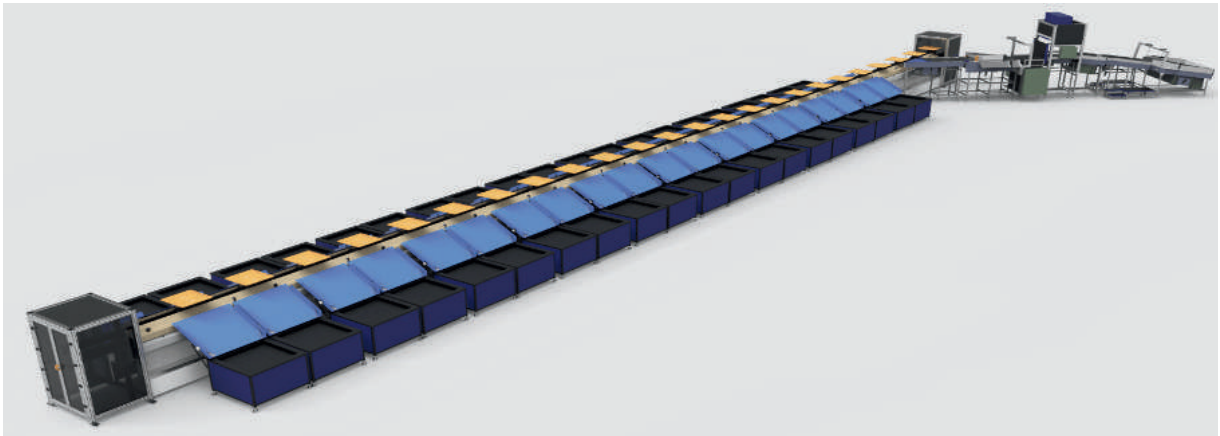
8.3.3. Sortation

Sortation is the process of identifying individual items on a conveyor system and diverting them to the correct locations using various devices controlled by task-specific software.

- **Cross Belt Sorter:** The Cross Belt Sorter delivers products with pinpoint accuracy using individual carriages, each with its own belt conveyor. Divert points are closely spaced, making the system very space-efficient.



- **Tilt Tray Sorter:** The Tilt Tray Sorter is a highly reliable and effective sortation system. It can be configured in a loop or linear setup, depending on the available floor space and the application's requirements. The system uses tilting trays and chutes to deliver products to assigned locations.



- **Pusher or Puller Sorter:** Pusher sorters are suitable for low to medium-throughput applications, especially for sorting irregularly shaped, difficult-to-convey items, and small items like polybags, cosmetics, or pharmaceuticals. These sorters have been in use for decades, offering a long history of reliable and accurate performance.

- **Line Sorter:** Line Sorter is a semi-automatic sortation solution for small and mid-size parcels. The solution may include a line camera or other devices for registering shipments and a conveyor belt with sortation mechanics, which deliver parcels to detachable bags according to the selected sort plan.

8.3.4. Movement

Automated Guided Vehicles (AGV): AGVs are material handling systems or load carriers that travel autonomously throughout a warehouse, without an onboard operator or driver. They perform tasks traditionally handled by forklifts, conveyor systems, or manual carts, moving large volumes of material repetitively.

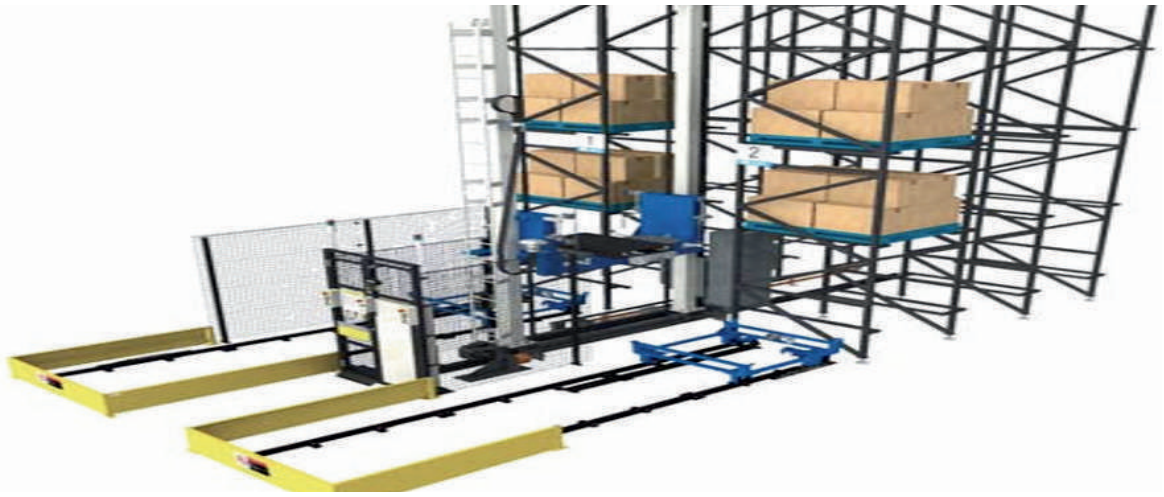
Types of AGVs include:
- Automated Guided Carts
- Forklift AGVs
- Towing AGVs
- Unit Load Handlers

- **Autonomous Mobile Robots (AMRs):** AMRs are generally more technologically advanced than other AGVs. While many AGVs use fixed navigation systems like wires or magnetic tape, AMRs are equipped with intelligent navigation capabilities such as sensors and camera systems. These enable AMRs to detect and navigate around obstacles, dynamically plan paths, and efficiently navigate a warehouse or facility.

8.3.5. Automated Storage & Retrieval System

Automated Storage and Retrieval Systems (ASRS or AS/RS) are computer-controlled systems that automatically place and retrieve loads from set storage locations in a facility with precision. The benefits of ASRS include increased throughput capabilities, accuracy levels up to 99.99%, enhanced labour productivity by up to 85%, improved ergonomics by delivering items at a convenient height, and reduced time lost to walking, searching, lifting, bending, and twisting activities. Additionally, ASRS improves storage density, product security, and real-time inventory control.
Types of ASRS include:

- **Unit-load ASRS:** Used for large loads such as cases or pallets, this system can handle loads weighing several thousand pounds. It utilises fixed-aisle and moveable-aisle cranes.



- **Mini-load ASRS:** Smaller than unit-load ASRS, these systems handle lighter loads and use shuttles and cranes, making them ideal for warehouses with narrow aisles.

- **Pallet Shuttle Racking System:** This high-density compact storage solution uses powered shuttles to automatically carry loads into the rack. The pallet shuttles are remotely controlled by an operator, optimize storage space and reducing workplace accident rates. This system can operate as FIFO (First In, First Out) or LIFO (Last In, First Out).

- **Mother & Child Shuttle System:** Also known as the Carrier-Shuttle system, this is a multi-deep ASRS solution generally used for high-density storage. The "Mother" vehicle carries a smaller "Child" shuttle along rails perpendicular to the aisles on each floor. The Child shuttle moves into the aisle to pick or place pallets as required. The system can then transfer the pallet to an outbound system like vertical lifts or conveyors.

8.3.6. Warehouse Control and Execution Systems

Warehouse Control Systems (WCS) and Warehouse Execution Systems (WES) are critical software components that bridge the gap between high-level warehouse management systems (WMS) and the automation equipment operating on the warehouse floor. While both systems are designed to optimize warehouse performance, they serve different but complementary functions.

- **Warehouse Control Systems (WCS):** WCS act as the real-time operational layer that interfaces directly with material handling equipment such as conveyors, sorters, ASRS units, and carousels. They execute commands issued by the WMS, ensuring synchronized operation across devices and real-time coordination for item movement. WCS can monitor equipment status, manage load distribution across systems, and respond dynamically to events like jams or faults. It is essential in highly automated environments to maintain continuity and efficiency.

- Use Case: In a fast-moving e-commerce fulfillment centre, the WCS optimizes conveyor speeds, sorting logic, and device sequencing, ensuring high-volume order processing without manual intervention.

- **Warehouse Execution Systems (WES):** WES sits between the WMS and the WCS layers and provides intelligence that adapts operations based on real-time demand and system capacity. WES dynamically manages workloads, allocates tasks to automation or human resources, and adjusts pick waves, replenishment cycles, or putaway based on system congestion or resource availability. Unlike traditional WMS that operate on batch logic, WES enables continuous flow and responsiveness.
  - Use Case: During a flash sale event, WES reprioritizes order processing based on shipping cut-off times and automation availability, ensuring high-priority orders are fulfilled first while balancing system load.

Together, WCS and WES create a responsive, agile, and data-driven operational environment that maximizes the performance of warehouse automation investments. such as order waving, replenishment prioritization, and dynamic reallocation of labour and machines during demand peaks.

8.4 Emerging Technologies

Artificial Intelligence (AI) and computer vision technologies are increasingly embedded into modern warehouse systems to drive efficiency, accuracy, and real-time decision-making. These tools support operational visibility, reduce dependency on manual processes, and enhance automation reliability. From intelligent label scanning to inventory tracking and worker activity monitoring, AI enables warehouses to become more agile, scalable, and safe. This section explores key applications of AI and machine vision across a variety of warehousing tasks.

- **Intelligent Scanning**

AI-powered vision systems outperform traditional barcode scanners by handling damaged, crumpled, or misaligned labels. These systems integrate with fixed scanning tunnels, mobile devices, or smart glasses and ensure near-100% scan accuracy.
  - Use Case: In a high-speed sortation hub, AI-based scanning improved label recognition accuracy from 88% to 99.7%, reducing delays and customer claims.

- **Inventory and Dock Door Visibility**

Machine vision deployed at dock doors verifies item count, packaging condition, and SKU match against outbound manifests. It also provides video audit trails for shipment disputes and loss prevention.
  - Use Case: A 3PL operation implemented dock cameras with AI analytics, reducing outbound mismatches by 25% and eliminating manual reconciliation steps.

- **Human Activity Monitoring**

Vision systems monitor manual processes like kitting, packing, and labelling. AI flags deviations in standard operating procedures (SOPs), improving accountability and training.
  - Use Case: A consumer electronics warehouse reduced repackaging errors by 40% after installing vision-based quality monitoring at packing stations.

- **Safety and Compliance**

AI detects whether safety protocols are being followed—e.g., use of helmets, vests, and gloves. Systems can also analyse forklift speed, sharp turns, and unauthorized zone entries.
  - Use Case: A cold chain warehouse integrated real-time safety alerts with LED floor indicators, cutting down safety violations by 60%.

- **Robotics and Drones**
  - Robotic Arms: Perform repetitive or hazardous tasks such as palletizing, depalletizing, or product kitting. Vision-guided robots ensure accurate item identification and placement.

- Drones: Conduct autonomous inventory audits in high racks or hard-to-reach locations. Equipped with cameras and barcode readers, drones reduce cycle count times.
- Limitations: Drones face constraints in battery life and visibility of nested SKUs.

- **Packaging, Sustainability, and Waste Reduction:** AI-powered tools optimize packaging by selecting the ideal box size and materials, reducing empty space, packaging waste, and shipping costs. Smart systems also track carton condition to determine reusability.

- **Traceability:** Outbound and inbound scans link packaging to routes and orders. Lifecycle tracking supports packaging reuse and end-of-life recovery.

- **ESG Compliance:** AI models generate audit-ready reports on packaging waste, CO_2 impact, and reuse metrics aligned with Packaging and Packaging Waste Regulations (PPWR).

Technology	Application	Equipment	Indian Manufacturers	Global Manufacturers
Telescopic Conveyor	Truck loading/unloading	Extendable belt conveyors	• Darshini Engineers • Vega Conveyors	• Caljan • FMH Conveyors
Pick-to-Light	Order picking	Light-guided pick modules	• GreyOrange • Falcon Autotech	• SSI Schaefer • KNAPP
AGVs	Material movement	Guided vehicles	• Hi-Tech Robotic Systemz • Addverb	• Daifuku • KUKA
AMRs	Dynamic navigation and picking	Autonomous mobile robots	• Addverb • GreyOrange	• Fetch Robotics Locus Robotics
ASRS - Unit Load	Pallet storage	Crane-based ASRS	• Godrej Storage • Stora Enso India	• Dematic • Daifuku
ASRS - Mini Load	Carton/tote storage	Shuttles and stacker cranes	• Falcon Autotech • Addverb	• Swisslog • SSI Schaefer
Vision-Based Scanning	Label reading, quality check	AI-powered camera systems	• Uncanny Vision • Qualitas Technologies	• Cognex • Zebra Technologies • KoiReader Technologies
Drones for Inventory	Stock audits	Inventory drones with scanners	• Aarav Unmanned Systems • Throttle Aerospace	• Ware • Verity AG
Voice Picking	Hands-free order picking	Voice-directed systems	• GreyOrange • Honeywell India	• Honeywell • Voxware
Digital Twin	Virtual warehouse modeling	Simulation and analytics platform	• Altizon • Flutura	• Siemens • Dassault Systèmes • KoiReader Technologies

09

Policy Thrust Areas

for Enabling Warehousing Ecosystem

1. Policy framework and warehousing integration
2. Key trust areas in State policies
3. Consolidated matrix of State Interventions
4. Conclusion and roadmap for policy alignment

Objectives and Outcomes

Objectives:

The primary objectives of this chapter are:

- **Policy Framework Understanding:** To familiarize readers with how State Logistics Policies (SLPs) incorporate warehousing as a critical component of the logistics ecosystem, aligned with the National Logistics Policy (NLP) 2022.
- **Best Practice Identification:** To outline policy interventions successfully adopted by different states in India, covering planning, infrastructure, incentives, and technology.
- **Strategic Alignment:** To highlight how warehousing policies can support national economic goals, encourage private sector participation, and enhance last-mile connectivity and sustainability.

Outcomes:

The intended outcomes from implementing the guidelines in this chapter are:

- **Informed Policy Application:** Users will understand how to interpret and apply successful warehousing-related provisions from existing SLPs in their respective regions or institutions.
- **Comprehensive View of State Interventions:** Readers will gain a synthesized understanding of how different Indian states have embedded warehousing interventions within broader logistics frameworks.
- **Ability to Identify Gaps and Replicate Interventions:** Users can identify best practices, address policy gaps, and propose or replicate suitable state-level interventions.
- **Awareness of Strategic Focus Areas:** Readers will become familiar with thrust areas such as industry recognition, land facilitation, fiscal incentives, grievance redressal, and sustainability-focused support.

Introduction

The warehousing sector is integral to the nation's logistics infrastructure, enhancing link between production and consumption. As demand surges for just-in-time deliveries, e-commerce, and integrated logistics solutions, the need for modern, efficient warehouses has become paramount to achieving economic and trade objectives. To fully capitalize on this potential, a comprehensive and forward-looking policy framework is essential—one that attracts private investment, supports sustainability, and promotes inclusive development.

Recognizing the strategic importance of warehousing as a subset of logistics, 26 Indian States and Union Territories have formulated State Logistics Policies (SLPs), while others are in the process of formulating them **(Annexure 06)**. These state-level strategies align with the National Logistics Policy (NLP) of 2022, which serves as a national blueprint aimed at reducing logistics costs, enhancing service delivery, and improving trade efficiency across sectors.

State logistics policies are designed to complement the NLP by addressing local bottlenecks and creating an enabling environment for private sector investment. They typically focus on:

- **Infrastructure Development:** Establishing logistics parks, multimodal hubs, and warehousing clusters to support integrated logistics solutions.
- **Fiscal Incentives:** Offering capital subsidies, tax reimbursements, and exemptions on land-related charges to attract investments.
- **Ease of Doing Business:** Implementing single-window clearance systems and simplifying regulatory approvals to reduce project delays.
- **Land and Infrastructure Provisioning:** Allocating land within industrial corridors and special economic zones, and promoting last-mile connectivity.
- **Skill Development:** Building a skilled workforce through training programs focused on logistics and warehousing operations.
- **Sustainability and Technology:** Encouraging green logistics, automation, and digital platforms for smarter, more efficient warehousing operations.

Instead of formulating separate warehousing-specific policies, States and Union Territories are encouraged to strengthen and operationalize their existing State Logistics Policies (SLPs) to drive warehousing development in their respective regions. Given that logistics encompasses the warehousing sector, a comprehensive and integrated approach through SLPs ensures better alignment with national priorities and promotes more efficient infrastructure planning.

The National Logistics Policy defines logistics as the transportation and handling of goods between points of production and consumption, along with associated functions such as storage, value addition, and allied services. Logistics infrastructure comprises interconnected nodes and links—such as ports, railway stations, Multimodal Logistics Parks (MMLPs), warehouses, and other commercial facilities—connected by networks of roads, railways, shipping routes, inland waterways, air corridors, and pipelines. This integrated system is managed through a robust framework and powered by a workforce equipped with diverse skills and technological capabilities.

Several states have already taken steps to embed warehousing-specific interventions within their broader logistics policies, including warehousing as a core component, focusing on infrastructure development, investment facilitation, multimodal connectivity, land-use provisions, fiscal incentives, private sector participation, and green infrastructure initiatives.

9.1 Focus Areas of the warehousing sector

Instead of proposing a one-size-fits-all "model policy," this section outlines pragmatic thrust areas and enabling interventions that has been proposed across Indian states in their respective SLPs. This section presents a comprehensive compilation of state-led policy measures categorized under key focus areas ranging from implementation planning and fiscal incentives to land facilitation and technological support. These measures are drawn from actual policy documents and initiatives implemented across several leading states.

Each focus area reflects an aspect of the enabling environment that contributes to the overall growth and modernization of the warehousing ecosystem. From recognition as an industry to provision of single-window clearances, from capital subsidies to promoting green infrastructure and skilling, these interventions together shape a robust policy foundation for warehousing in India.

This collation, therefore, is not a prescriptive model policy but a practical compilation, of what other states have done so far in the warehousing sector. The matrix below outlines the initiatives, their descriptions, and examples of reference states that have taken lead in implementing these policies.

Implementation and Planning

S. No.	Focus Area	Description	Reference State
A.1	**Recognition as 'Industry'**	According 'industry' status to Warehouses to promote ease of doing business and enable them to avail various benefits provided by the States, including industrial land use and FAR benefits, subsidized electricity and power rates, etc. This will reduce the cost of setting up business for the warehousing industry.	Haryana, Maharashtra and Uttar Pradesh
A.2	**Establishment of Nodal Department/ Co-ordination Committee/ State Warehousing Cell**	A dedicated agency is proposed with the following features: • Framing and executing the broad strategies for Warehouse development. • Such dedicated agency shall be responsible for attracting investors and playing a key role in the implementation of the respective State's warehousing policy. • Facilitation of 'Single Window Clearance Mechanism'. • Providing grievance redressal to the investors and industry stakeholders. • Coordination with other State authorities and agencies for the disbursement of incentives and subsidies.	Punjab, Tamil Nadu, Gujarat, Maharashtra
A.3	**Single Window Clearance System**	A Single Window Clearance Mechanism is proposed with following features: Setting up fast-track mechanism for submission of applications of regulatory approvals, NOCs and clearances for setting up and operating Warehouses, and fiscal incentives, including renewals and deemed approval.	Haryana, Punjab, Uttar Pradesh
A.4	**White Category Status**	Given that certain warehousing activities have lower pollution footprint and waste generation, the state of Uttar Pradesh has categorized the warehousing activity as 'White Category'.	Uttar Pradesh

The State Governments may be encouraged to coordinate and work closely on the development and expansion of the Warehouse Sector.

Fiscal Incentives

S. No.	Focus Area	Description	Reference State
B.1	**Electricity Duty Exemption**	100% exemption on electricity duty for a period ranging between 5-15 years.	Punjab, Uttar Pradesh, Haryana, Gujarat
B.2	**Stamp Duty exemption**	100% reimbursement/ exemption of stamp duty on purchase or lease of land/ building.	Punjab, Uttar Pradesh, Haryana, Gujarat
B.3	**Capital Subsidy**	Financial assistance at the rate of 15-25% of fixed capital investment to be provided to Warehouses, with a maximum cap ranging between INR 5 crores to INR 15 crores.	Haryana, Uttar Pradesh, Tamil Nadu, Gujarat
B.4	**Interest Subsidy**	Financial assistance in the form of interest subvention at the rate of 5-7% on loan taken to meet working capital requirements subject to a maximum cap ranging between INR 10 lakhs to INR 50 lakhs per year for 3-7 years.	Gujarat and Haryana
B.5	**Exemption on External Development Charges**	Exemption on External Development Charges (EDC) between the range of 50-100%.	Haryana, Uttar Pradesh and Punjab
B.6	**Exemption on Change in Land Use (CLU)/ Land Use Conversion**	75-100% exemption or concession on land use conversion charges.	Uttar Pradesh and Punjab
B.7	**Reimbursement of Cost for Quality Certification of Warehouses**	Reimbursement shall be provided at the rate of 50% of cost for Quality Certification paid – upto a maximum of INR 5 lakhs to INR 10 lakhs per project.	Gujarat and Uttar Pradesh

Land related Incentives

S. No.	Focus Area	Description	Reference State
C.1	**Fast Track land Allotment**	Land allocation on fast-track basis for setting up a new project within industrial areas upon meeting certain minimum capital investment threshold.	Uttar Pradesh
C.2	**Land Allocation/ Dedicated Spaces**	Earmarking a certain percentage (for instance at least 10%, or 10 acres) of the land area in all upcoming industrial parks for dedicated warehousing activities.	Punjab and Tamil Nadu
C.3	**Higher Ground Coverage**	Maximum permissible ground coverage for all units should be increased. For instance, in states like Haryana and Uttar Pradesh, the maximum permissible ground coverage is 60%, while in Maharashtra the maximum limit is 75%.	Haryana, Uttar Pradesh and Maharashtra
C.4	**Relaxation on Height Restrictions**	Maximum permissible height for development of Warehouses should be increased. For instance, Tamil Nadu aims to increase the maximum limit up to 24m.	Tamil Nadu and Maharashtra

Other Benefits and Support Mechanisms

S. No.	Focus Area	Description	Reference State
D.1	24x7 Operations	Warehousing facilities allowed to operate 24x7 to offer better last mile connectivity.	Punjab, Tamil Nadu, Uttar Pradesh, and Haryana
D.2	Women Employment	Women employees permitted to work in all shifts, including night shifts with their consent, along with all safety, transportation and other measures for such female employees as may be prescribed by the respective State's labour department.	Uttar Pradesh, Haryana and Punjab
D.3	Grievance Redressal Mechanism	A dedicated grievance redressal mechanism for the industry to report issues pertaining to warehousing should be institutionalised.	Tamil Nadu, Gujarat and Punjab
D.4	Power Availability	Last-mile-connectivity and access to critical utilities such as power should be made available and expedited for Warehouses.	Uttar Pradesh, Gujarat and Punjab
D.5	Sustainability Support	The Policy also advocates for private investments for adopting green measures in the warehousing industry and encourage adoption of sustainable design standards and greening solutions. This also includes the State's endeavour to promote captive solar power generation by allowing open access to warehousing industry. In this regard, for adopting green and sustainable measures, subsidies may also be given on such green capital investments. For instance, Tamil Nadu provides a subsidy at the rate of 25% on cost of capital for setting up and undertaking such initiatives, subject to a cap of INR 5 crores.	Uttar Pradesh, Tamil Nadu, Punjab and Gujarat
D.6	Skilling	The Policy promotes excellence and upskilling, re-skilling and capacity enhancement of the workforce to cater to the needs of the Warehouse industry. This may be done by way of establishing Warehousing Innovation Centres, Centres of Excellence, and developing curriculum and training courses. Warehousing enterprises may also be encouraged to conduct skill development and training programmes for the rural youth.	Punjab, Tamil Nadu, Uttar Pradesh, Gujarat, Maharashtra and Haryana
D.7	Innovation and Incentives for Leveraging Technology	The Policy encourages Warehouses to adopt state of the art technologies and establish smart warehousing practices by promoting adoption of technology and modern practices to enable automation, green logistics and safety. This includes encouraging research & development, promoting of digitization techniques, robotics and automation in the Warehousing industry.	Punjab, Gujarat, Uttar Pradesh and Tamil Nadu

This consolidated table of policy thrust areas reflects a diverse approach being employed by Indian states to enhance the competitiveness of the warehousing sector.

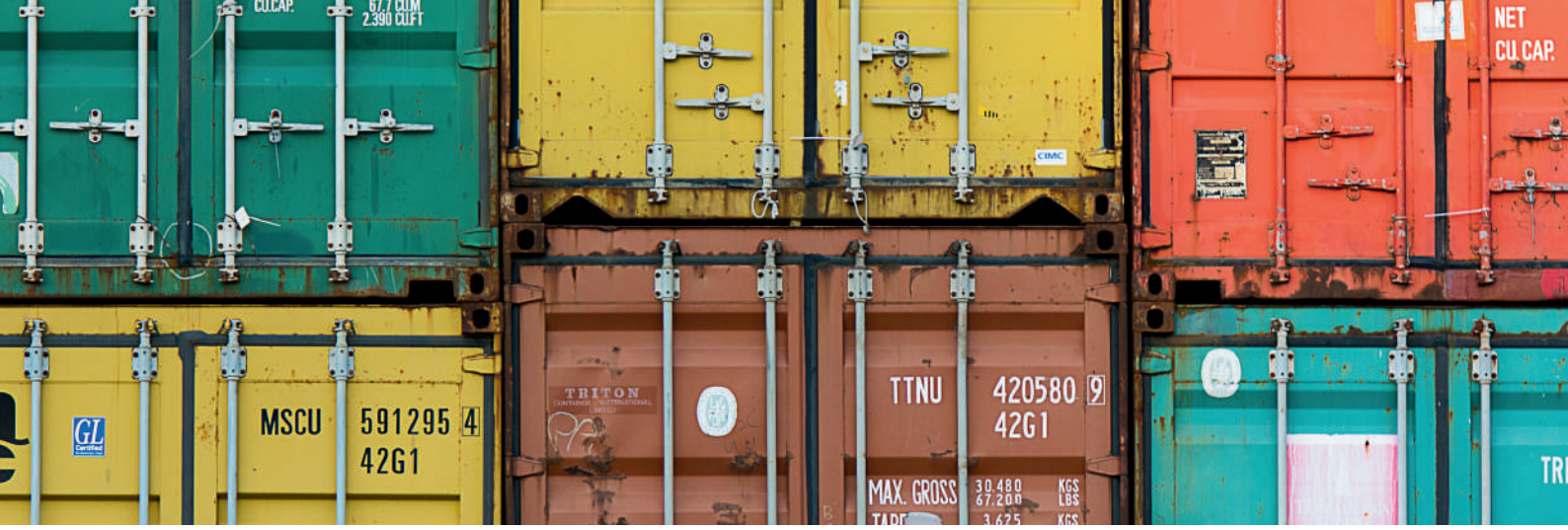
Conclusion-

A dynamic policy framework is critical to unlocking India's warehousing potential. By strategically enhancing State Logistics Policies with warehousing-focused measures, States and Union Territories can foster resilient, efficient, and sustainable warehousing ecosystems. The best practices and interventions highlighted in this chapter offer a flexible roadmap for addressing infrastructure, regulatory, fiscal, and operational challenges, while supporting national priorities under the PM GatiShakti National Master Plan and the National Logistics Policy.

Adopting these approaches will not only lower logistics costs and attract private investment but also promote innovation, employment, and environmentally responsible growth. Ultimately, a proactive, integrated policy framework for warehousing will accelerate India's logistics transformation and strengthen its position in the global supply chain.

10

Case Studies



Introduction

The following case studies illustrate real-world applications of the standards and best practices outlined in the "Warehousing Standards Handbook." Each case study provides a detailed examination of specific challenges faced by companies in different industries, the solutions they implemented, and the outcomes achieved. By showcasing these examples, we aim to provide a comprehensive understanding of how these standards can be practically applied to optimise warehouse operations, enhance efficiency, and ensure compliance with regulatory requirements.

These case studies serve as valuable learning tools, offering insights into the strategic decision-making processes and innovative approaches adopted by industry leaders. They highlight the importance of technology integration, sustainability measures, and adherence to regulatory standards, demonstrating how these elements contribute to overall operational success.

The examples include:

Case Study: *Streamlining Operations with Advanced Material Handling and Automation - the successful implementation of advanced material handling systems and automation technologies to improve operational efficiency, safety, and inventory accuracy at Loadstar Logistics.*

Case Study: *Implementing Automation and Sustainability in a Warehouse Facility - CargoSwift Systems' journey to integrate advanced automation technologies and sustainable practices, ensuring high efficiency and regulatory compliance.*

Case Study: *Optimizing Inventory Management and Warehouse Layout - Innovix Electronics' strategic initiatives to improve inventory accuracy, space utilization, and order fulfillment speed.*

These case studies not only illustrate successful implementations but also provide actionable insights and recommendations for other organisations seeking to enhance their warehousing and logistics operations.

Case Study: Streamlining Operations with Advanced Material Handling and Automation

The case study of LoadStar Logistics illustrates the transformative impact of advanced material handling and automation technologies on warehouse operations. By adhering to the standards and guidelines outlined in the "e-handbook on Warehousing Standards 2025" the company significantly enhanced its operational efficiency, safety, and accuracy. This example serves as a valuable reference for other businesses looking to modernise their warehousing practices and embrace technological advancements.

Background

LoadStar Logistics, a company specialising in consumer electronics, faced challenges related to order fulfillment speed, accuracy, and space utilization. With increasing demand and a growing product range, the company needed to optimise its warehouse operations to maintain competitive service levels.

Implementation and Standards

1. **Material Handling Equipment Standards (Chapter 4)**:
   - **Automated Storage and Retrieval Systems (AS/RS)**: LoadStar Logistics installed AS/RS to streamline the storage and retrieval of small and medium-sized products. This system, compliant with the standards outlined in Chapter 4, improved space utilization and reduced the time needed for picking and packing orders.
   - Automated Guided Vehicles (AGVs): The introduction of AGVs facilitated the automatic movement of goods within the warehouse. These vehicles, adhering to the safety and operational standards in the handbook, minimised manual handling, reducing the risk of accidents and product damage.
2. **Automation and Robotics (Chapter 5):**
   - **Robotic Picking Systems:** The company integrated robotic arms for picking high-demand products. These robots were programmed to handle items with varying shapes and sizes, ensuring precision and efficiency. The implementation followed the guidelines for automation and robotics, focusing on improving order accuracy and reducing labor costs.
   - **Warehouse Management System (WMS)**: A state-of-the-art WMS was deployed to manage inventory levels, order processing, and real-time tracking. The WMS was critical in coordinating the activities of AS/RS and AGVs, ensuring seamless integration and efficient operations.
3. **Safety and Ergonomics (Chapter 2)**:
   - To complement the technological upgrades, LoadStar Logistics also focused on enhancing workplace safety and ergonomics. This included installing ergonomic workstations for manual handling tasks and ensuring proper safety signage and training for staff interacting with automated systems.

Results

The implementation of advanced material handling equipment and automation technologies resulted in significant operational improvements:

- **Increased Throughput**: The facility's throughput increased by 40%, allowing the company to handle more orders with greater speed and accuracy.
- **Reduced Operational Costs**: Automation reduced the need for manual labor, resulting in a 25% decrease in operational costs.
- **Improved Inventory Accuracy**: The integration of a WMS and AS/RS improved inventory accuracy to 99.9%, reducing stock discrepancies and improving order fulfillment accuracy.
- **Enhanced Safety**: The adoption of safety standards and ergonomic practices led to a 30% reduction in workplace injuries, creating a safer working environment for employees.

Case Study: Implementing Automation and Sustainability in a Warehouse Facility

This case study demonstrates the successful application of the standards outlined in the "Warehousing Standards Handbook" by CargoSwift Systems and serves as a model for other companies seeking to optimize their warehouse operations.

Background

CargoSwift Systems is a mid-sized logistics company specialising in e-commerce fulfillment. The company has recently expanded its operations and needs a new warehouse to accommodate the increased demand. The goal is to design a warehouse that meets the highest standards of efficiency, sustainability, and safety while adhering to the guidelines outlined in the "Warehousing Standards Handbook."

Challenge

The key challenges for CargoSwift Systems include:

- Automation Integration: To streamline operations and reduce manual labor costs, CargoSwift Systems aims to implement advanced automation technologies.
- Sustainability: The company seeks to minimise its environmental footprint by incorporating sustainable practices and materials.
- Regulatory Compliance: Ensuring that the new warehouse meets all applicable standards and regulations, including those for safety, palletization, and energy efficiency.

Solution

1. **Automation Implementation**
   To enhance operational efficiency, CargoSwift Systems implemented several automation solutions, including:
   - **Telescopic Conveyor Systems:** For efficient loading and unloading of goods, telescopic conveyor systems were installed. These systems can extend from the warehouse to the truck, minimising manual handling and speeding up the loading process.
   - **Warehouse Management System (WMS):** A WMS was integrated with IoT sensors and RFID tags for real-time inventory tracking and data analysis. This system enables efficient inventory management, reduces errors, and optimizes warehouse space utilization.
   - **Picking Automation:** Put-to-Light systems were employed for order picking. These systems use light signals to guide workers, thereby improving picking accuracy and speed.

2. **Sustainability Measures**
   CargoSwift Systems incorporated various sustainability measures in the warehouse design:
   - **Solar Panels:** Solar panels were installed on the roof to generate renewable energy, covering at least 25% of the warehouse's energy needs. This initiative not only reduces energy costs but also minimises reliance on non-renewable energy sources.
   - **Water Conservation:** The warehouse implemented a rainwater harvesting system to collect and reuse water for non-potable applications, such as landscape irrigation. Additionally, a sewage treatment plant was installed to recycle water for flushing.
   - **Sustainable Building Materials:** The use of recycled materials, such as fly ash bricks and reclaimed wood, was prioritized in the construction process. This approach helped reduce the carbon footprint and embodied energy of the building materials.

3. **Regulatory Compliance**
   CargoSwift Systems ensured compliance with various standards as outlined in the "Warehousing standards Handbook," including:
   - **Palletization Standards:** The warehouse adhered to the BIS standards for pallet dimensions and materials, ensuring efficient space utilization and safety. Standardised pallets were used to facilitate automation and minimise manual handling.

- **Safety and Security:** The facility was equipped with state-of-the-art fire safety systems, including sprinklers and smoke detectors. Security measures, such as CCTV surveillance and controlled access points, were also implemented to safeguard the inventory.

Results

- The implementation of automation and sustainability measures resulted in significant operational efficiencies and cost savings. The warehouse's energy costs were reduced by 20%, while the automated systems increased order processing speed by 30%. Additionally, the sustainable practices adopted by CargoSwift Systems earned the company a green building certification, enhancing its reputation as an environmentally responsible organisation.

Case Study: Optimizing Inventory Management and Warehouse Layout

The case study demonstrates the practical application of standards and best practices from the "Warehousing Standards Handbook," showcasing the benefits of technology integration and strategic planning in warehouse operations. Innovix Electronics' experience serves as a valuable example for other companies looking to optimize their logistics and distribution processes.

Background

Innovix Electronics is a leading distributor of consumer electronics, handling a wide range of products from smartphones to home appliances. The company's warehouse operations had become increasingly complex due to a growing product portfolio and fluctuating demand. Innovix Electronics sought to optimise its inventory management and warehouse layout to improve efficiency and reduce operational costs.

Challenges

Innovix Electronics faced several key challenges:

1. Inventory Accuracy: Frequent discrepancies between physical stock and system records led to stockouts, overstocking, and lost sales.
2. Space Utilization: Inefficient use of warehouse space caused congestion and delays in picking and shipping.
3. Order Fulfillment Speed: Slow order processing times impacted customer satisfaction and limited the company's ability to scale operations.

Solution

1. Inventory Management System (IMS) Enhancement

To address inventory accuracy issues, Innovix Electronics upgraded its Inventory Management System with the following features:

- **RFID Technology:** The implementation of RFID tags on all products enabled real-time tracking of inventory levels and locations. This technology reduced human error in inventory counts and provided precise data on stock availability.
- **Automated Replenishment:** The IMS was integrated with an automated replenishment system that monitored inventory levels and triggered restocking orders based on predefined thresholds. This system ensured that high-demand items were always in stock, while minimising excess inventory.

2. Warehouse Layout Optimization

Innovix Electronics conducted a comprehensive analysis of its warehouse layout and implemented several changes to improve space utilization and workflow efficiency:

- **Zoning:** The warehouse was divided into zones based on product type, size, and demand frequency. High-demand items were placed closer to the packing and shipping area, reducing picking time and travel distance.
- **Vertical Storage Solutions:** The company installed high-density shelving units and pallet racks, maximizing vertical space. This solution increased storage capacity without expanding the warehouse footprint.
- **Cross-Docking:** A cross-docking area was established to facilitate the immediate transfer of incoming shipments to outbound trucks, minimising storage time and handling.

3. **Process Automation and Workflow Streamlining**
   To further enhance efficiency, Innovix Electronics adopted several process automation and workflow improvements:
   - **Automated Guided Vehicles (AGVs):** AGVs were deployed to transport goods between different areas of the warehouse, reducing manual handling and labor costs.
   - **Voice-Picking Technology:** Voice-picking systems were implemented to guide warehouse staff through the picking process using voice commands. This technology improved picking accuracy and speed, while allowing employees to work hands-free.

Results

The optimization of inventory management and warehouse layout led to significant improvements in operational efficiency. Inventory accuracy improved by 30%, reducing stockouts and overstock situations. The optimised layout and automated systems decreased order fulfillment times by 40%, enhancing customer satisfaction and enabling Innovix Electronics to handle a higher volume of orders.

11

Annexures & Glossary

1. Annexure 01: Warehouse Standards
2. Annexure 02: Design / Construction / Maintenance of Structures
3. Annexure 03: Floor Parameters and Standards
4. Annexure 04:Signage Guidelines
5. Annexure 05: MHE Standards/ Guidelines
6. Annexure 06: Indian States with Warehousing Policies

ANNEXURE - 01 - WAREHOUSE STANDARDS

A	Civil Work	Specifications
1	**Perimeter Wall**	Precast Concrete panels or brick & mortar wall or autoclaved aerated concrete block masonry 3.00m to 3.90m height from finished floor level with damp proofing.
2	**Plinth Height (Finished Floor Level - FFL)**	FFL to be kept at +1200 mm from the Finished Road Level (FRL) at loading / unloading side of the warehouse with the assumption that dock leveller at 1200 mm will have +/- 300 mm inclination (with max 3 meter length) to cater to 12' vehicles to 40' trailers.
3	**Warehouse Entrance**	Façade - Glazing with ACP cladding. Entrance - With granite finish with 900mm height SS railing Ramp - 1.2 meter wide with 1:12 slope in broom finish concrete/granite finish with handrails on both sides.
4	**Truck Apron Area**	The external docking yard or apron in front of the warehouse loading bay should be minimum of 30m in depth for perpendicular docking and 19m in case of angular docking through the full length of the warehouse building. The apron should be constructed for handling heavy vehicle traffic movement.
5	**Toilets**	Fully functional toilets to be provided in the warehouse building based on user layout as per NBC requirements. Considering male: female occupancy ratio.
6	**Diesel Generator (DG) Platform**	DG platform to be provided as per the user's DG dimensions and weight. The DG exhaust stack foundation should be provided.
7	**Anti - Termite Treatment**	Anti-Termite treatment should be done in the foundations right up to the plinth beam to ensure extermination of all termites to prevent future infestation. Treatment should also be done to the sub-base of the warehouse floor.
8	**Tests & Reports**	The following surveys and tests should be done before commencement of construction and reports to be shared with and considered by the civil engineering team while designing: a. Topographical survey b. Soil test reports c. Hydrogeological survey d. Plate load tests on soling or on finished sub-base before start of flooring. Test quantity and target values to be specified by floor designer.

B	Warehouse Flooring	Specifications
1	**Flooring Standards**	TR:34 Edition IV / ICI TC 09 / ACI 302 / ACI 360
2	**Floor Design Input**	Floor load should be calculated on the basis of: • The product attributes (such as weight & dimensions) and the unit load device on which it is placed. • If placed on standard pallets of size 1000mm x 1200mm or 1200mm x 1200mm then the weight of the loaded pallet should be converted to load (Kg) per square meter. • If the warehouse will store material on high rise heavy duty racking system or multi-tier shelving systems then it is necessary to calculate the load (kgs/m^2) on the upright (column) of the storage system. When communicated for design the load should be stated along with the size of the base plate on which the upright is installed. • The type of MHE(s) that could to be used to operate the racking system should be factored for their wheel spacing and loaded MHE(s) weight transferred on wheels for dynamic and static calculations for the purpose of floor design.
3	**Floor Surface Regulations**	TR:34 Edition IV / ICI TC 09 / ASTM E 1155 / FEM 9.381 / DIN 18202
4	**Reinforcement**	TR 34 / ICI TC 09
5	**Densification / polishing on Floor**	Nano/Lithium/Sodium silicate systems should be used wherever necessary. The system increasing the Mohr's scale hardness should be used.

C	PEB Works	Specifications
1	**Structure**	Pre-engineered building,
2	**Building Clear Height (at eaves)**	From 9m to 16m clear or as per product stacking requirement.
3	**External Bay Dimension**	8.20m to 8.80m
4	**Internal Bay Dimension**	16.40m to 17.60m x 22m to 25m
5	**Mezzanine Structure**	Minimum 5% of total plinth area. Dead Load as per design, Live Load for office can be considered as 3.5 KN/Sqm and for value added services a minimum of 5.0 KN/Sqm. The deck sheet can be considered as .80mm thick 345 Mpa Galvalume sheet.
6	**Dead Load - Building**	0.15 KN/Sqm as per IS 875 (Part 1):1987
7	**Collateral Load - For Building**	Minimum 0.30 KN/Sqm
8	**Collateral Load - For Mezzanine**	Minimum 0.15 KN/Sqm
9	**Live Load**	0.57 KN / Sqm
10	**Wind Speed**	As per IS 875:2015
11	**Wind load application**	As per IS 875:2015
12	**Seismic code**	IS 1893:2016 Part 1
13	**Design Codes**	1. Loads (other than ones mentioned above) as per MBMA (2012) 2. Design code as per AISC 2010 edition. 3. Frame members are to be designed in accordance with AISC 2010 edition. 4. Cold Formed members are to be designed in accordance with AISI, 2012 edition. 5. All welding work shall be in accordance with the AWS (American Welding Society) for the relevant procedures. 6. All Welders should be qualified for the type of welds performed.
14	**Deflection Criteria**	As per design
15	**Steel specification for primary members**	ASTM A572 M Grade 345 Mpa, minimum tensile strength to be 345 Mpa / AISI 2010 ASD 345 Mpa
16	**Steel specification for secondary members**	ASTM A 653/A 653M Grade 340 with coating as per Z275 standard and minimum yield strength of 345 Mpa / AISI 2010 345 Mpa.

	PEB Works	Specifications
17	**Roof**	· Roof sheet of the warehouse should be made of Galvalume steel, in heat reflective colour. In case of green building certification, use GreenPro Certified standing seam roof. · Roof slope is determined based on rainfall data however slope ranges from 1:20 to 1:10. · Minimum thickness of 0.55mm TCT, standing seam roof, in single length sheets from ridge to eves. No breaks are allowed. 360 degree seamed roofing system with no end laps, with metal end closures at eve. Conforming to ASTM A792M, AZ150 grade 275.
18	**Louvers**	Louvers of appropriate size to be provided on the wall cladding with bird mesh to prevent bird ingress.
19	**Building Ventilation**	Minimum 6 air changes / hour through an adequately designed roof monitor and louvers in the wall cladding to support the required number of air changes.
20	**Canopy**	Minimum 4.50m deep for buildings with perpendicular docking and 6m deep for buildings with angular docking. The canopy to be cantilevered and back stays can be provided for additional support. Canopy to be minimum 5.20m from the finished road level (FRL).
21	**Sky Lights**	3% -5% of roof area, polycarbonate sheet with underdeck mesh (for fall protection) with waterproofed design. Wall lights should also be provided for lighting to compensate for any reduction in sky lights.
22	**Insulation**	• Sandwich air bubble insulation of minimum 8mm thickness with double core with minimum R value of 3.10 Sqm K/W / Rock wool insulation of 16 Kg/Cu. Mtr, density with 50mm thickness and aluminium facing on exterior side / 9mm XLPE with single side aluminium foil can be installed on roof and wall of the building. • Glasswool of 16 to 24kg/cum density, 50mm thick, WMP 50 or Aluminium foil or FSK facing. • Can also use sustainable high Solar reflectance Index (SRI) paint on roof and wall surfaces.
23	**Wind Bracings**	There should not be any wind bracings in the warehouse area that obstructs material or MHE movement. Wind bracings to be provided above wall height or at a height that does not obstruct any movement. Bracings can be provided from the floor level on the side where there are no dock doors or any other movement.
24	**Provision for fixing Solar Panels on PEB roof**	15 to 20 kg/sq.mt. dead load to be added to the building design for providing the necessary fixing clips for the solar panels.
25	**Cage ladders**	The PEB building should be provided with a permanently fixed cage ladder with a door and locking mechanism on 2 sides of the warehouse building to access the roof of the warehouse.
26	**Building Roof Life Line System**	A lifeline system should be provided at ~~both ends~~ entire roof periphery & both sides of the roof monitor of the building to facilitate and secure people maintaining the roof and solar panels.

D	Dock Equipment	Specifications
1	**Dock Doors Numbers & Shutter Type**	1 in 10,000 square feet. Minimum 2 Manual / Electrically operated MS / GI rolling shutter with a manual override option.
2	**Dock Door Width x Height (meters)**	For perpendicular docks - 2.4 m x 3.0 m / For angular docks - 3.0m x 3.0m
3	**Dock Shelters**	Dock shelters to be provided on the walls for perpendicular docks to avoid damage to the walls, ingress of dust during operations and prevent loss of temperature in air-conditioned warehouse. Dock shelter size to be as per the dock opening size.
4	**MHE Dock Doors**	There should be 1 door in each warehouse to enable MHE equipment to move outside the warehouse. Size of these doors should be minimum 4m (wide) x 5m (height) and should be connected to ramps suitable for the equipment being used in warehouse. This door should be electrically operated with a manual override. This door should be constructed with MS of minimum 1mm thickness OR a PUF infilled sectional door can be used.
5	**Fire Escape Doors with Panic Bar and alarm**	The numbers and locations should be provided as per NBC and local fire codes. Each fire door should have a minimum 2 hour fire rating. A Panic Bar to be provided on the Inside (warehouse side) of the door leaf.
6	**Dock Guards/Bumpers**	02 numbers per dock
7	**Dock Levelers**	30% of dock doors to be provided with dock levelers and 100% dock doors to be provided with dock pits.

E	Electrical Works	Specifications
1	**Power**	Power connection up to building as per 1.00 kVA to 1.25 kVA per 1,000 sq. ft. of building space.
2	**Power Back Up**	The complex should have power back up facility (DG Set) to light the common roads and yard. Also to provide power to security gates, boundary wall, common structures, water pumps and fire pumps, etc.
3	**Lightning Arrestor**	Since lighting is the major source of energy consumption in all buildings, energy efficient LED lighting should be considered. Uniformity in indoor applications as per National Lighting Code 2010 / 2016 should be maintained. Internal Lighting • Lighting is generally designed based on IS: 3646 standards. Lighting design is based on room dimensions, colours of wall / ceiling, height of ceiling, type of false ceiling and type of activity in the rooms. External Lighting • External lighting should be provided using LED lamps, mounted on masts, columns and building faces as required to wash the building walls and light specific areas. • The luminaries should be segregated on circuits so that separate area control can be achieved. These individual areas should be provided with time clock and auto/manual/off controls with photo electronic facilities. • Pathways and general pedestrian paths may be lit by means of low-level bollard type luminaries if desired. External Lights should be separately controlled and should not have any connections with the warehouse light panels. Lighting levels in principal areas are generally as in following table: Area Description/Considered Lux Level • MHE parking, charging & servicing area: 200-250 • Shelving / staging area: 200-250 • Heavy Duty Racking Aisles: 150 – 200 • Toilets:150 • Under Canopy and Docking Yards: 100 • Truck apron area: 50 The illumination levels can be measured between 0.80m to 1m from the finished floor level.
4	**Emergency Lighting (10% of the total general lightning & all emergency exits)**	Emergency lighting should be provided to permit safe evacuation of the building in case of an emergency. The systems should provide for multiple central battery systems operating at 50V DC. Local inverters should invert to 240V AC and illuminate emergency luminaries sited at strategic positions.
6	**CCTV Surveillance**	Server based intelligent video management CCTV system with reputed software interface or NVR based with port switches which will depend on the quantity and location demands; can be considered at park level.

F	Fire Fighting Works	Specifications
1	**Sprinklers**	Sprinkler of ELO or LD type of reputed make and can be integrated with fire alarm system. C Class pipes and fittings, heavy grade pipes as per IS:1293A should be used. Provision for tap off for in-rack sprinklers should be provided. The local governing norms should be checked and followed to ensure the firefighting system is compliant.
2	**External Fire Hydrant System**	Fire hydrant system and First Aid Hose Reel design as per IS13039:2014.All hydrant points shall be installed 2m away from the face of the building and placed 30 m apart. The pipes and hydrant points shall be strategically placed and protected wherever required to avoid any damages due to truck or vehicular movement. External fire hydrant ring should be fed from multiple connections to the Fire Hydrant Water Tank. Fire hydrant points should be provided following the Local fire norms. The external hydrant system should be approved by the concerning authority.
3	**Internal Hydrant Systems**	Should be designed as per local and NBC codes. All hydrant valves shall be conforming to IS:5290 and shall be of reputed brands. Rigid supporting systems for overhung pipes using galvanised support should be provided with C class pipes and fittings, (heavy grade pipes as per IS1239A.) and valves and appurtenance shall be of reputed brands and installed in accessible locations.
4	**Hose Reel & Fire Extinguisher**	First aid hose reel drum shall be conforming to IS:884 and the tubing shall be high quality thermoplastic, conforming to IS:12585.Hose reel drum shall have a provision to swivel 180 degrees to address the hazard swiftly and efficiently. Extinguishers shall be provided in all common areas as per IS:2190 and shall conform to IS15683.

G	Common Infrastructure	Specifications
1	**Park Boundary Wall**	8ft high precast / UCR wall with 2ft of concertina wire. A 'Y' shaped vertical post extension for placement of the concertina coil.
2	**Internal Roads**	Bitumen finish / Pavement Quality Concrete/Paver Blocks (IRC 57 for bitumen roads & IRC 58 for concrete roads)
3	**Office Entrance**	There should be a separate entrance for the office area, and this should not be common with the goods movement / vehicle gate entry and exit. The staircase can have granite steps with 900mm high MS railing. The pathway to the entrance and the entrance itself should be covered.
4	**Truck Parking Area**	A truck terminal / parking area should be provided at a common location in the logistics park. Parking lanes should be highlighted to specify parking areas. Rest rooms and washrooms should be provided near the truck parking / terminal area.
5	**Visitor/Staff Parking**	Visitor and staff parking to be provided as per applicable development control regulations (DCR)
6	**Entrance ramp for handicap access to the buildings**	1.2m wide with 1:20 ramp with MS railings on both sides.
7	**Storm Water Drainage**	Should be designed as per NBC, the local rainfall data and local DCR norms. Design Reference: CPHEEO manual
8	**Fresh Water supply**	Provision of 30 litre per person per day as per NBC code.
9	**Flushing water supply (treated STP water)**	Based on 15 litre per day per person can be considered.
10	**STP**	Based on 45 or 30 liters per day per person as per NBC guidelines can be considered. Online monitoring should comply with local administrative guidelines.
11	**Total Population**	Total population accordance with standard specification ratio of 1:1000 sq. ft. building space per day including all shifts.
12	**Utility Space**	Well graded & levelled open space
13	**Security Cabins**	• The warehouse will have 2 security cabins on each side of the warehouse with wash room as primary security control arrangement. These Security cabins should be at least 60 ft^2 in size. • The Secondary security post of the complex will be at the main entrance gate
14	**Entry and Exit Gates**	Entry exit gates for each WH in a park will be a challenge from design perspective (setbacks, etc) and space management hence retain for Park level
15	**Admin / Facility Office**	May be provided on need base.
16	**Rainwater Harvesting**	As per statutory requirement.

	Common Infrastructure	Specifications
17	**Protection Kerbs or Kerbs Stone**	Protection kerbs are to be provided on the warehouse side edges and exposed columns to prevent damage by heavy vehicles. The same should also be provided between vehicles at loading docks to ensure alignment with back stop building protection.
18	**Landscaping**	All landscaping, ground formations, planting and seeding is to be carried out in accordance with the local authority requirements.
19	**Line Markings and External Road Information and Direction Signage**	Signage on entrance, roads, warehouse main entrance, objects, items - reflective, non-reflective signages. (Post Fitout Period)
20	**Utility and Scrap Area**	Electrical room, scrap storage, maintenance store should be provided around the warehouse at appropriate locations.
21	**EV Charging points**	Should be provided for private and cargo vehicles as per local building norms.

ANNEXURE - 02 – DESIGN / CONSTRUCTION / MAINTENANCE OF STRUCTURES

Standards / Guidelines	Issuing Authority
Guidelines for Group H: Storage and Warehousing Occupancy Guidelines in National Building Code of India 2016 (NBC 2016) including Part 6 'Structural Design'	Bureau of Indian Standards
Fire safety standards as prescribed by the Bureau of IndianStandards	Bureau of Indian Standards
Water drainage mechanism, methods for rainwater harvesting as per Bureau of Indian Standards	Bureau of Indian Standards
Standards for Effluent Discharge as per NBC 2016 (Part 9)	Bureau of Indian Standards
Standards for Solid Waste Management	Bureau of Indian Standards
Fire safety of Industrial Buildings (IS 3594)	Bureau of Indian Standards
Code for practice for interior illumination (IS 3646 Part 1)	Bureau of Indian Standards
Code of Practice for Plain & Reinforced Concrete (IS 456)	Bureau of Indian Standards
General Construction in Steel-Code of Practice (IS 800)	Bureau of Indian Standards
Code of Practice for Composite Construction in Structural Steel and Concrete (IS 11384)	Bureau of Indian Standards
Code of Practice for use of cold-Formed light gauge steel structural members in general building construction (IS 801)	Bureau of Indian Standards
Code of Practice for Design Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks (IS 803)	Bureau of Indian Standards
Silos for grain storage (IS 5503 Part 1 and 2)	Bureau of Indian Standards
Criteria for design of reinforced concrete bins for the storage of granular and powdery materials (IS 4995 Part 1 and Part 2)	Bureau of Indian Standards
Criteria for Design of Steel Bins for Storage of Bulk Materials - Part 1 : General Requirements and Assessment of Loads ; Part 2 : Design Criteria; Part 3 : Bins Designed for Mass Flow and Funnel Flow (IS 9178 (Part 1 to 3)	Bureau of Indian Standards
Design, fabrication, testing and installation of underground storage/ tank storages (IS 10987)	Bureau of Indian Standards
BIS Guidelines for Improvement of existing structures used or intended to be used for food grain storage (IS 609), Dunnage pallet warehousing (IS 13714)	Bureau of Indian Standards
Foodgrain storage godowns – Code of Practice (IS 16144)	Bureau of Indian Standards
Portable Fire Extinguishers (IS 15683)	Bureau of Indian Standards

Standards / Guidelines	Issuing Authority
Selection, Installation and Maintenance of First Aid Fire Extinguishers (IS 2190)	**Bureau of Indian Standards**
Installation of Surveillance equipment confirming to BIS 13252 (Information Technology Equipment-Safety)	Bureau of Indian Standards
Guidelines for improving cyclonic resistance of low-rise houses and other structures (IS 15498)	Bureau of Indian Standards
Landslide control Guidelines for structures in Hilly regions (IS 14680)	Bureau of Indian Standards
Criteria for earthquake resistant design of structures [IS 1893 (Part 1) and IS 1893 (Part 4)]	Bureau of Indian Standards
Code of practice for design loads (Other Than Earthquake) for buildings and structures: Part 1 dead loads - Unit weights of building materials and stored materials [IS 875 (Part 1)]	Bureau of Indian Standards
Code of practice for design loads (Other Than Earthquake) for buildings and structures: Part 2 imposed loads [IS 875 (Part 2)]	Bureau of Indian Standards
Design Loads (Other than Earthquake) for Buildings and Structures - Code of Practice Part 3 Wind Loads [IS 875 (Part 3)]	Bureau of Indian Standards
Code of practice for design loads (Other Than Earthquake) for buildings and structures: Part 4 snow loads [IS 875 (Part 4)]	Bureau of Indian Standards
Code of practice for design loads (Other Than Earthquake) for buildings and structures: Part 5 special loads and load combinations [IS 875 (Part 5)]	Bureau of Indian Standards
Building Design and Erection Using Prefabricated Concrete - Code of Practice (IS 15916)	Bureau of Indian Standards
NBC 2016: Part 8/Sec 1 'Lighting and Natural Ventilation'	Bureau of Indian Standards
NBC 2016 : Part 6 'Structural design' Sec1 to 8)	Bureau of Indian Standards
NBC 2016 (Part 12) Asset and facility management	Bureau of Indian Standards
Thermal insulation of cold storage - Code of practice (IS 661)	Bureau of Indian Standards
The Air (Prevention and Control of Pollution) Act, 1981	Central Pollution Control Board
The Water (Prevention and Control of Pollution) Act, 1974	Central Pollution Control Board
Noise Pollution (Regulation and Control) Rules, 2000	Central Pollution Control Board
The Environment (Protection) Act, 1986	Central Pollution Control Board

Standards / Guidelines	Issuing Authority
Guidelines issued by CWC	CWC
Guidelines issued by FCI	FCI
Guidelines under Food Safety Management System by FSSAI	FSSAI
Standards by National Centre for Cold Chain Development	National Centre for Cold Chain Development
WDRA Warehouse Registration Rules, 2017 (Rule 20 for Infrastructure requirements of Warehouses)	Warehousing Development and Regulatory Authority
Petroleum, petrochemical and natural gas industries — Internal coating and lining of steel storage tanks (ISO 16961)	ISO
ISO 22311:2012 Standards for Societal Security- Video Surveillance system	ISO
Design Codes for Built-up section and HR sections	American Institute of Steel Construction
Design Codes for Cold rolled section for roofing	American Iron and Steel Institute
RP 1604 (Closure of Underground petroleum storage tanks)	American Petroleum Institute (API)
RP 1615 (Installation of Underground Petroleum storage tanks)	American Petroleum Institute (API)
RP 1631(Interior lining and periodic inspection)	American Petroleum Institute (API)
RP 1632 (Cathodic protection of underground tanks)	American Petroleum Institute (API)
EN BS 8204-2:2002 and ASTM C779 and ASTM C944 for abrasion resistance	European Standards
Guidelines under International Tanker Container Organisation	International Tanker Container Organisation
Loading codes under MBMA	Metal Building Manufacturers Association
Guidelines under National Leak Prevention Association Standards for Entry, Cleaning, Repair of Underground Storage Tanks (NLPA Std 631)	National Leak Prevention Association, USA
Construction standards based on provisions laid down under the Warehousing (Development and Regulation) Act, 2007 and subsequent rules and regulations framed there under by the Warehousing Development and Regulatory Authority including Warehousing (Development and Regulation) Registration of Warehouses Rules and Warehousing and Regulatory Authority (Electronic Negotiable Warehouse Receipts) Regulations, 2017	Warehousing Development and Regulatory Authority

Comprehensive infrastructure checklist for open areas, parking, and dock infrastructure

General Planning & Zoning Compliance

Item	Requirement	Standard/Guideline
Land Use Zoning	Must conform to industrial/logistics zoning	Local Development Control Regulations (DCR)
Setbacks & Open Space	As per local authority (e.g., MIDC, GIDC)	NBC 2016, local DCR
FSI/FAR Utilization	Check max permissible FSI & coverage	Planning Authority norms

Open Storage Yards

Item	Requirement	Standard/Guideline
Paving	RCC or interlocking blocks with sub-base; no loose surfaces	NBC 2016 Part 3
Drainage	1–2% slope; stormwater inlets at low points	IS 3370, CPHEEO Manual
Boundary Fencing	2.4 m min height fencing with security gate	MoSPI/CPWD norms
Dust Control	Water sprinklers, green barriers for dusty materials	CPCB Guidelines
Fire Safety Access	6 m minimum clear access; turning radius 9 m	NBC 2016, Part 4
Stacking Safety	Height limits based on material; stack on pallets or plinth	IS 875 (Part 2), IS 4963

Vehicle Parking & Circulation

Item	Requirement	Standard/Guideline
Dimensions	Car: 2.5×5.0 m; Truck: 3.75×12 m; 6 m driveways	NBC 2016, IRC SP-12
EV Provision	20% spaces with EV charging infra (recommended)	MoHUA Guidelines
Signage & Marking	Painted bays, arrows, entry/exit clearly marked	IRC: 35-1997
Drainage	Graded surfaces with drain traps; oil separators in truck areas	IS 9271
Accessible Parking	1 in every 25 bays near entrances	Harmonized Guidelines for PwDs
Lighting	20 lux minimum; pole spacing ~25 m	IS 1944 Part 1

Dock Infrastructure & Equipment

Item	Requirement	Standard/Guideline
Dock Height	1.2 m for standard trucks; can vary by vehicle type	Industry Practice
Apron Area	12–15 m depth; non-slippery RCC surface	IS 4651 Part 5
Dock Levelers	6–10T capacity; automatic/manual options	ANSI MH30.1
Shelters & Seals	Must prevent rain ingress, energy loss	OSHA, FM Global
Safety	Wheel chocks, dock bumpers, barrier chains	IS 3696, OSHA dock safety
Drainage	Away from dock door; catchpits with gratings	IS 456, NBC drainage norms

Utilities and Misc. Open Infrastructure

Item	Requirement	Standard/Guideline
Stormwater Management	Recharge pits, RCC drains, silt traps, culverts	CPHEEO Manual
Lighting	Pole-mounted LED (IP65), min 20 lux avg	IS 1944 Part 1
Security & Surveillance	CCTV at entry/exits, open areas, docks	MHA Smart Infra Guidelines
Solid Waste Yard	Segregated bins, collection points as per SWM Rules 2016	MoEFCC
Fire Fighting Access	6 m wide motorable path; hydrants at 45 m intervals	NBC Part 4
Utility Trenches	Labeled & accessible; avoid overlaps	IS 12592
Green Buffer	5–10% open area with trees, shrubs; native species	CPCB EC Conditions

Safety & Environmental Compliance

Item	Requirement	Standard/Guideline
Fire Extinguishers	At docks, open yards; class-specific	NBC, IS 2190
Hazardous Materials	Separated storage zones, spill kits	MSIHC Rules, 1989
Noise & Air Monitoring	Required if near residential zones	CPCB Norms
First Aid & Assembly	Emergency stations near open yards	Factory Rules

ANNEXURE 03 - FLOOR PARAMETERS AND STANDARDS

Sr. No.	Floor Parameter	Standards/Methods	Remarks
1	Subgrade / Subbase	IS 1888, IS 2914, Proctor Density, Plate Load Test	The sub-base thickness and floor topping is derived by this input. A floor cannot be laid if sub-grade value is less than 2% as it may require piling or some other support before the floor can be laid.
2	Slip Membrane	300 microns virgin LDPE	This should not be considered as a vapour barrier. It is a separation layer between the concrete and the sub-base. Double layer slip membrane may be used in case recommended by the flooring consultant based on design.
3	Concrete	IS 456/IS 10262 for mix design TR 34, ICI TC 09 for workability	Workability and finishing aspects are more important than mechanical properties of the concrete. Concrete with fly ash content to be avoided.
4	Floor Design Standards	TR 34 / ICI TC 09	TR 34: IV Edition and ICI TC 09 are both sufficient and perfect documents for floor design however other design documents like ACI 302, ACI 360 can also be consulted as per discretion of Engineer in Charge. Floor design should be done by a flooring consultant or a design and build contractor.
5	Floor Surface Regulations *	TR 34 / ICI TC 09	TR-34: IV Edition and ICI TC 09 are both sufficient and perfect documents for defining surface regulations covering all aspects of MHE. Other documents like ASTM E 1155, FEM 9.381 and DIN 18202 can also be used to satisfy MHE load requirements. However, floor surface regulations should be defined by storage system height and the MHE. The surface regularity should only be measured by authorised flooring consultant / survey company with the necessary equipment.
6	Reinforcement (Rebar / Fiber (Steel, Plastic)	TR34: IV Edition /ICI TC 09	Minimum rebar reinforcement should be 8mm x 150mm x 150mm, minimum fibre reinforcement dosage should be capable of giving 30 % RE value.
7	Load Transfer / Floor Joints	Armour joints with studs, arris protection and plate dowels	All joints which will be in the access path of the MHE should be armoured to protect the arris and prevent breakage of edges.

Sr. No.	Floor Parameter	Standards/Methods	Remarks
8	Sealants	Polyurethane sealant during construction Stage. Modified Epoxy /Semi Rigid Epoxy Sealant After 12-18 Months	
9	Floor Screeding Methods	Laser operated screed machine	Where laser operated screeding machine is not available truss screed can be used for areas less than 5000 m^2.
10	Floor Protection Systems		
10-A	Abrasion Resistance - Non Metallic Hardener	Suggested dosage - 5 kg / Square Metre	BS 8204 / ICI TC 09 Min 4 KG /M^2 should be used or as advised by the floor designer.
10-B	Densification and Polishing	Nano/Lithium/Sodium systems can be used. A system which increased Mohrs scale hardness can be used.	A measured performance system such as US Polishing Council guidelines is preferred but not mandatory.
11	Resin coatings	BS 8204, HACCP, USDA& CFTRI, DIN51130 & TRPL	A PU coating is preferred over epoxy coating.
12	Curing	LDPE sheets of 75 micron or curing mats, watering 3 times a day for 7 days / curing compound to be used as advised by the manufacturer.	Use of curing compound should be avoided when additional floor protection system such as densification, polishing and resin coating is planned.
13	Flooring consultant	A qualified flooring engineer with sufficient first-hand experience of floor design and execution	
14	Flooring Contractor	A flooring contractor with design and build experience of constructing floors.	

ANNEXURE 04 - SIGNAGE GUIDELINES

vinyl graphics Only
Size : 30 cm x 45 cm
Qty : 05

3 mm thick ACP Panel with vinyl graphics
Size : 30 cm x 45 cm
Qty : 04

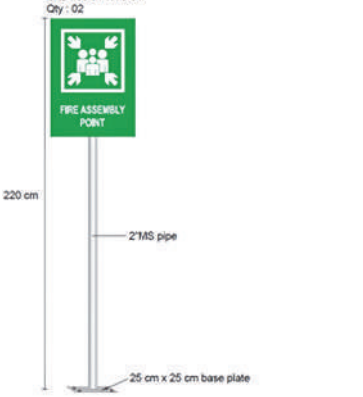
1.8 mm aluminum powdercoated panel with vinyl graphics
Size : 60 cm x 100 cm
Qty : 02

1.8 mm aluminum powdercoated panel with vinyl graphics
Size : 40 cm x 60 cm
Qty : 02

3 mm thick ACP Panel with vinyl graphics
Size : 40 cm x 60 cm
Qty : 02

3 mm thick ACP Panel with vinyl graphics
Size : 40 cm x 30 cm
Qty : 06

1.8 mm aluminum powdercoated panel with vinyl graphics fixing on 2" MS pipe with base plate
Size : 50 cm x 70 cm
Qty : 02



3 mm thick ACP Panel with vinyl graphics
Size : 30 cm x 45 cm
Qty : 04

3 mm thick ACP Panel with
vinyl graphics
Size : 50 cm x 15 cm
Qty : 01

3 mm thick white acrylic Panel with
vinyl graphics
Size : 30 cm x 10 cm
Qty : 03

1.8 mm aluminum powdercoated panel
with vinyl graphics
Size : 30 cm x 30 cm
Qty : 04

1.8 mm aluminum powdercoated panel with
Reflective vinyl graphics
Size : 45 cm x 45 cm
Qty : 18

1.8 mm aluminum powdercoated panel
with vinyl graphics
Size : 30 cm x 15 cm
Qty : 08

3 mm thick ACP Panel with
vinyl graphics
Size : 40 cm x 30 cm
Qty : 16

vinyl graphics Only
Size : 30 cm x 15 cm
Qty : 10

vinyl graphics Only
Size : 30 cm x 15 cm
Qty : 3

1.8 mm aluminum powdercoated panel
with vinyl graphics
Size : 40 cm x 30 cm
Qty : 06

ANNEXURE 05 – MHE STANDARDS/GUIDELINES

Standard	Description / Requirement
IS 10517	Acceptance Criteria for Forklift Trucks
IS 11757	General requirements and acceptance criteria for forklift trucks with capacity from 10000 kg to 50000 kg
IS 4660	Powered Industrial Trucks - Terminology
IS 8005	Classification of unit loads
IS 6765	Powered industrial trucks parameters for designation of rated capacity and capacity
ISO 13564-1	Powered industrial trucks - test methods for verification of visibility
IS 6305-1	Safety code for powered industrial trucks - Part 1 - Application, Operation and Maintenance
IS 6305 2	Safety Code for powered industrial trucks - Part 2
IS 7862	Glossary of terms relating to safety aspects concerning operating areas of industrial trucks
IS 7496	Direction of Travel-controls for Industrial Tractors and Powered Industrial Trucks
SAEJ 898	Control locations for off-road work machines
IS 7553	Control symbols for powered industrial trucks
IS/ISO 6405-1, 2	Common and specific symbols for operator controls and other displays
IS/ISO 9244	Compliance of machine safety labels
IS 15488	Powered Industrial Trucks - Safety Signs and Hazard Pictorials – General Principles
IS 8790-2	General requirements of powered industrial trucks working in hazardous areas, Part 2 Electric battery powered industrial trucks
IS 6876	Fork - Lift trucks - Fork arms - Technical characteristics and testing (Second Revision)
IS 7621	High lift rider trucks - overhead guards - Specification and testing
IS 4357	Industrial trucks - Counter balanced trucks with mast - Verification of stability
IS 7309	Industrial trucks - Verification of stability reach and straddle trucks
IS 7631	Industrial trucks - Pallet stackers, double stackers and order - Picking trucks with operator position elevating up to and including 1200 mm lift height - Verification of stability
IS 9075	Stability tests for side loader trucks
IS 14770	Industrial trucks - repairs and maintenance of fork arms in service on forklift trucks
IS 7570	Glossary of terms relating to fork arms and attachments of forklift trucks

IS 7525	Fork - Lift trucks - Hook - On type fork arms and fork arm carriages - Mounting dimensions
ISO 2328	Hook on type Fork Arms and Carriage
IS 15634	Forks-arm extensions and telescopic fork-arm - Technical characteristics and strength requirements
ISO 1585	Road vehicles - Engine test code - Net power
ISO 9249	Earthmoving machinery - Engine test code - Net power
ISO 8178	Exhaust emission measurement for non-road engine applications
DIN 72551-6	Low tension cables for off-road vehicles
DIN 72551	Compliance for electrical wiring
IS 15487	Industrial Trucks - Indicator Lights for container handling and Grappler Arm operations
ISO 6055	Specification and testing standards for overhead guards
ISO 13849	Safety of machinery - safety related parts of control systems
IS 7570	Glossary of terms relating to fork arms and attachments of forklift trucks
IS 7525	Fork - Lift trucks - Hook - On type fork arms and fork arm carriages - Mounting dimensions
ISO 2328	Hook on type Fork Arms and Carriage
IS 15634	Forks-arm extensions and telescopic fork-arm - Technical characteristics and strength requirements
ISO 1585	Road vehicles - Engine test code - Net power
ISO 9249	Earthmoving machinery - Engine test code - Net power
ISO 8178	Exhaust emission measurement for non-road engine applications
DIN 72551-6	Low tension cables for off-road vehicles
DIN 72551	Compliance for electrical wiring
IS 15487	Industrial Trucks - Indicator Lights for container handling and Grappler Arm operations
ISO 6055	Specification and testing standards for overhead guards
ISO 13849	Safety of machinery - safety related parts of control systems
ISO 20898	Electrical requirements of industrial trucks
ISO 3691-3	Additional requirement of trucks with elevated operator position and specifically designed to travel with elevated loads
IS 10311	General requirements of powered platform trucks and their acceptance criteria

IS 8049	Specification for platform trucks
IS 10312	Safety code for powered tow trucks
IS 6839-2	Glossary of terms relating to non-powered materials handling equipment, Part 2 Hand trucks and trolleys
IS 11496	General and performance test requirements of pallet truck and stillage truck
IS 10517	Acceptance criteria for forklift trucks
IS 10312	Safety code for powered tow trucks
IS 11757	General requirements and acceptance criteria for forklift trucks with capacity from 10000 kg to 50000 kg
IS 12726	Industrial trucks - Order - Picking trucks with operator position elevating above 1200 mm - Verification of stability
IS 14770	Industrial Trucks- Inspection and Repair of Fork-arms in Service on Forklift trucks
IS 15487	Industrial Trucks- Indicator Lights for container handling and Grappler Arm operations
IS 15488	Powered Industrial Trucks- Safety Signs and Hazard Pictorials - General Principles
IS 15611-1	Single side loading Forklift trucks, Part 1: Stability tests
IS 15611-2	Single side loading Forklift trucks, Part 2: Additional Stability tests for trucks handling freight containers of 6m length and above
IS 15634	Forklift Trucks- Fork arm extensions and telescopic fork arm- Technical characteristics and strength requirements
IS 15640	Bi-Directional Multi directional forklift trucks- Stability tests
IS 4357	Industrial trucks - Counter balanced trucks with mast - Verification of stability
IS 6876	Fork - Lift trucks - Fork arms - Technical characteristics and testing
IS 7309	Industrial trucks - Verification of stability reach and straddle
IS 7525	Fork - Lift trucks - Hook - On type fork arms and fork arm carriages – Mounting dimensions
IS 7570	Glossary of terms relating to fork arms and attachments of forklift trucks
IS 8790-1	General requirements of powered industrial trucks working in hazardous areas: Part 1 internal combustion engine powered trucks
IS 8790-2	General requirements of powered industrial trucks working in hazardous areas, Part 2 Electric battery powered industrial trucks

ANNEXURE 06 - INDIAN STATES WITH WAREHOUSING POLICIES

26 Indian states have notified their state logistics policy to strengthen logistics and warehousing infrastructure. The table below provides a reference list:

S. No	State	Policy	Link
1	**Andaman & Nicobar Islands**	A & N Islands logistics policy, 2023	https://dpiit.gov.in/sites/default/files/AndmanNicobar_26October2023.pdf
2	**Andhra Pradesh**	Andhra Pradesh Logistics Policy, 2022	https://www.apindustries.gov.in/apindus/Data/GO/AP_Logistics_Policy_2022_27_GO_Ms_No_23.pdf
3	**Arunachal Pradesh**	Arunachal Pradesh Logistics Policy 2023	https://dpiit.gov.in/sites/default/files/LogisticsPolicy_NotificationAP_29February2024.pdf
4	**Assam**	Assam Logistics and Warehousing Policy, 2022	https://industries.assam.gov.in/sites/default/files/swf_utility_folder/departments/industries_com_oid_4/portlet/level_2/assamlogistics_and_warehousing_policy-2022.pdf
5	**Bihar**	Bihar Logistics Policy, 2023	https://egazette.bih.nic.in/GazettePublished/1002_2_2023.pdf
6	**Chhattisgarh**	Logistics Park Policy	https://logistics.gov.in/media/stateut/Chattisgarh.pdf
7	**Goa**	Goa Logistics and Warehousing Policy, 2023	https://www.goaipb.goa.gov.in/wp-content/uploads/2024/01/Goa-Logistics-and-warehousing-Policy-2023.pdf
8	**Gujarat**	Gujarat Integrated Logistics and Logistics Park Policy, 2021	https://imd.gujarat.gov.in/Document/2021-7-20_769.pdf
9	**Haryana**	Logistics Warehousing and Retail Policy, 2019	https://logistics.gov.in/media/stateut/Haryana.pdf
10	**Himachal Pradesh**	Himachal Pradesh Logistics Policy, 2022	https://static.investindia.gov.in/s3fs-public/2022-10/HimachalPradesh_28July2022.pdf
11	**Jharkhand**	Jharkhand Industrial Park and Logistic Policy, 2022	https://uncomplycate.com/wp-content/uploads/2022/10/Jharkhand-Industrial-Park-and-Logistic-Policy-2022.pdf
12	**Karnataka**	Karnataka State Logistics Plan - 2022	https://dpiit.gov.in/sites/default/files/Karnataka_28Aug2024.pdf
13	**Kerala**	Draft Kerala Logistics Parks Policy, 2024	https://www.ksidc.org/wp-content/uploads/2024/03/Kerala-State-Logistics-Park-Policy-draft-04-March-2024-1.pdf
14	**Maharashtra**	Maharashtra's Logistics Parks Policy, 2018	https://www.midcindia.org/wp-content/uploads/2021/09/Maharashtra-Logistics-Policy-2018_compressed.pdf

S. No	State	Policy	Link
15	**Madhya Pradesh**	Madhya Pradesh	https://dpiit.gov.in/sites/default/files/MadhyaPradesh_SLP_03March20252023.pdf
16	**Manipur**	Manipur Integrated Logistics Policy, 2022	https://www.nsws.gov.in/s3fs/2022-12/manipur_integrated_logistics_policy_2022_0.pdf
17	**Mizoram**	Mizoram State Logistics Policy, 2022	https://industries.mizoram.gov.in/uploads/attachments/2022/08/43cfed31d3ebdcc9e36142f71d64670f/pages-150-the-mizoram-state-logistics-policy-2022.pdf
18	**Odisha**	Odisha Logistics Policy, 2022	https://investodisha.gov.in/download/Logistics-Policy-2022.pdf
19	**Puducherry**	Puducherry integrated logistics Infrastructure, multimodal Logistics park and warehouse Policy, 2023	https://dpiit.gov.in/sites/default/files/LogisticsPolicy_Puducherry_29February2024.pdf
20	**Punjab**	Integrated Logistics and Logistics Park Policy, 2023	https://dgrpg.punjab.gov.in/wp-content/uploads/2023/07/Integrated-Logistics-Policy-2023.pdf
21	**Tamil Nadu**	Tamil Nadu Logistics Policy and Integrated Logistics Plan	https://cms.tn.gov.in/sites/default/files/go/ind_e_73_2023.pdf
22	**Tripura**	Tripura Integrated Logistics Policy, 2022	https://dpiit.gov.in/sites/default/files/Tripura_21September2023.pdf
23	**Telangana**	Telangana State Logistics Guidelines, 2021	https://invest.telangana.gov.in/wp-content/uploads/2021/08/logistics-policy-2021.pdf
24	**Uttar Pradesh**	Uttar Pradesh Warehousing and Logistics Policy, 2022	https://invest.up.gov.in/wp-content/uploads/2023/02/Uttar_Pradesh_Warehousing_Logistics_Policy_2022.pdf
25	**Uttarakhand**	Uttarakhand Logistics Policy, 2023	https://investuttarakhand.uk.gov.in/themes/backend/acts/act_english1676890303.pdf
26	**West Bengal**	Draft West Bengal Logistics Policy	https://wbindustries.gov.in/policies-schemes/Notification_for_West_Bengal_Logistics_Policy.pdf

GLOSSARY

- **Accessorial Charges:** Additional fees added to freight bills for services beyond standard transportation, such as inside delivery, liftgate service, or residential delivery.
- **Advanced Planning and Scheduling (APS):** A system that helps businesses plan and schedule their production, distribution, and transportation activities to maximise efficiency and meet demand.
- **Artificial Intelligence (AI) in Logistics:** The use of AI technologies, like machine learning and predictive analytics, to optimise supply chain operations, such as demand forecasting, route optimization, and warehouse automation.
- **API (Application Programming Interface):** A set of tools and protocols that allow different software applications to communicate with each other, often used in integrating warehouse management systems with other platforms.
- **AIDC (Automatic Identification and Data Capture):** Technologies like RFID, barcodes, and QR codes that automatically identify and collect data about objects without human intervention.
- **ASN (Advanced Shipping Notice):** A document sent to the recipient of a shipment in advance, detailing the contents and expected arrival time, allowing better planning for receiving the goods.
- **Automated Storage and Retrieval Systems (AS/RS):** Systems that automatically place and retrieve goods in and from storage locations, optimize space and increasing efficiency in warehouses.
- **Backhaul:** The return trip of a truck after delivering goods, often used to transport goods back to the starting location to maximise transportation efficiency.
- **Backorder:** A situation where an order cannot be fulfilled due to insufficient stock, requiring it to be placed on hold until inventory is replenished.
- **Barcode:** A machine-readable representation of data, typically used for product identification and tracking within a warehouse.
- **Batch Picking:** A warehouse picking strategy where multiple orders are picked together in batches to reduce the number of trips taken to storage areas.
- **BOL (Bill of Lading):** A document that serves as a receipt of goods for shipment, as well as a contract and title, between the shipper and the carrier.
- **Bonded Warehouse:** A secured warehouse, usually under customs supervision, where imported goods can be stored without payment of duties until they are released for sale or export.
- **Bulk Cargo:** Large quantities of goods that are stored or transported unpackaged, often in tanks, bins, or containers. Examples include oil, grain, or coal.
- **Bulk Storage:** The storage of large quantities of homogeneous products in a warehouse, usually on pallets or in bins, without individual packaging.
- **Carrier:** The entity or company responsible for the transportation of goods, whether by land, sea, or air.
- **Cold Chain:** A temperature-controlled supply chain that ensures products like food, pharmaceuticals, and chemicals are stored and transported within safe temperature ranges to prevent spoilage.
- **Consignment Stock:** Inventory that is held by a retailer or distributor but remains owned by the supplier until it is sold.
- **Consolidation:** The process of combining multiple smaller shipments into a single, larger one to reduce shipping costs and improve efficiency.
- **Cross-Docking:** A process where products from incoming shipments are directly transferred to outbound transportation without being stored, reducing handling and storage time.
- **Customs Broker:** A licensed agent who assists companies in clearing goods through customs, ensuring compliance with all import and export regulations.
- **Cycle Counting:** A method of inventory counting where a portion of the stock is counted regularly to maintain accuracy.
- **Dead Stock:** Inventory that has not been sold or used for a long time, often obsolete or out-of-season products, which may require liquidation.
- **Dimensional Weight (DIM Weight):** A pricing technique used by freight carriers, where the cost is calculated based on the size of the package rather than its actual weight, to account for bulky but lightweight items.

- **DC (Distribution Center):** A warehouse where goods are received, processed, and distributed to retailers, consumers, or other destinations.
- **Direct Store Delivery (DSD):** A distribution method where products are delivered directly from the supplier to retail stores without passing through a distribution center.
- **Drop Shipping:** A retail fulfillment method where the seller does not keep products in stock but instead transfers orders to a third party, which ships the products directly to the customer.
- **Drop Trailer:** A logistics strategy where a trailer is dropped off at a shipper's location for loading or unloading and later picked up by a driver to minimise downtime.
- **EDI (Electronic Data Interchange):** The electronic exchange of business documents between organisations in a standardised format, often used in logistics and supply chain management.
- **Electronic Proof of Delivery (ePOD):** A digital confirmation that goods have been delivered, often captured through mobile devices, which enhances transparency and tracking in the delivery process.
- **ERP (Enterprise Resource Planning):** Integrated management software used by businesses to collect, store, manage, and interpret data from various business activities, including inventory, production, and logistics.
- **First-Party Logistics (1PL):** Logistics activities that are conducted by the company itself without the involvement of any external service providers. This involves managing the entire logistics process, from warehousing to delivery, internally.
- **FIFO (First In, First Out):** An inventory management method where the oldest stock is sold or used first, ensuring items are used within their shelf life.
- **Fixed Slot Location:** A warehousing strategy where specific products are always stored in the same designated spot, improving ease of access but potentially underutilising space compared to dynamic slotting.
- **Forklift Telemetry:** The use of sensors and data-gathering technology on forklifts to track and optimise their performance, maintenance, and usage in the warehouse.
- **Freight Forwarder:** A company or agent that arranges the shipping of goods for businesses, acting as an intermediary between the shipper and various transportation services (air, sea, rail, or truck.
- **Gross Weight:** The total weight of a shipment, including the weight of the goods, packaging, and any additional materials like pallets or containers.
- **GS1:** An organisation that develops and maintains global standards for business communication, including barcodes and RFID tags.
- **Hazmat (Hazardous Materials):** Substances that are potentially dangerous to health, property, or the environment, requiring special handling, labeling, and transportation measures.
- **In-Transit Inventory:** Goods that are in the process of being transported from one location to another, typically from the supplier to the distribution center or from the warehouse to the customer.
- **Just-in-Time (JIT):** A logistics strategy where materials are ordered and received only as needed in the production process, minimising storage costs.
- **Kanban:** A scheduling system used in inventory management and lean manufacturing to ensure that materials are only produced or ordered when needed, minimising waste.
- **Kitting:** The process of grouping individual items into kits, which are then shipped together. This is often used in assembly line production or to simplify the picking process in warehouses.
- **Labeling Compliance:** Ensuring that all products and shipments have the appropriate labels for identification, handling, and regulatory purposes.
- **LIFO (Last In, First Out):** An inventory management method where the most recently received items are used or sold first.
- **Last-Mile Delivery:** The final step in the delivery process where a product is transported from a distribution hub to the end customer.

- **Lead Time:** The amount of time between placing an order and receiving it. In logistics, reducing lead times is crucial for just-in-time (JIT) inventory systems.
- **Less-than-Truckload (LTL):** A freight transportation option for shipments that do not require a full truckload, allowing multiple small shipments to share space on the same truck.
- **Logistics Service Provider (LSP):** A company that offers logistics services such as warehousing, transportation, and supply chain management. LSPs can include both 3PL and 4PL providers.
- **Material Handling:** The movement, protection, storage, and control of materials and products throughout the manufacturing, warehousing, and distribution process.
- **Ocean Freight:** The shipment of goods by sea, typically used for large volumes of international cargo.
- **Omnichannel Fulfillment:** A fulfillment strategy where retailers integrate their physical stores and online platforms to provide seamless customer experiences
- **Order Fulfillment:** The complete process from receiving an order to delivering it to the customer, including order processing, picking, packing, shipping, and tracking.
- **Outsourcing:** The practice of hiring external companies to handle specific business operations, such as logistics and supply chain management, to improve efficiency and reduce costs.
- **Pallet Racking:** A storage system designed to hold materials on pallets, utilising vertical space to store products more efficiently in warehouses.
- **Periodic Inventory System:** A method where inventory levels are updated at specific intervals rather than continuously, which may lead to discrepancies between actual stock levels and recorded inventory.
- **Packing List:** A document that details the items included in a shipment, often used by both the shipper and the recipient to ensure accuracy in fulfillment.
- **Pick and Pack:** A warehouse process where products are picked from shelves and packed for shipment in a single operation.
- **Pick-by-Voice (Voice-Directed Warehousing):** A hands-free picking system where warehouse employees receive voice commands via headsets to guide them to the correct location and quantity for order fulfillment.
- **Private Warehouse:** A storage facility owned and operated by a single company for the exclusive use of their goods, often found in large corporations managing their own logistics.
- **Public Warehouse:** A storage facility that rents space to multiple businesses, allowing companies to store goods on a short- or long-term basis without owning their own warehouse.
- **Putaway:** The process of moving received goods from the receiving dock to their designated storage location within a warehouse.
- **Real-Time Inventory Management:** A system that tracks inventory levels in real time, often using RFID, barcode scanners, or IoT devices to ensure up-to-date and accurate stock counts.
- **Replenishment:** The process of restocking inventory in specific areas of the warehouse, either to meet demand for outgoing orders or to maintain optimal stock levels.
- **Reverse Logistics:** The process of handling returned goods, including returning them to stock, refurbishing, or recycling them.
- **RFID Reader:** A device that scans RFID tags to capture and transmit data about an item's location, identity, or other information.
- **RTLS (Real-Time Location Systems):** Technology that tracks the real-time location of objects or people within a defined area, commonly.
- **Route Optimization:** The use of software and algorithms to determine the most efficient routes for deliveries, reducing transportation costs and delivery times.
- **Safety Stock:** Extra inventory held to protect against unexpected demand surges or supply chain disruptions, ensuring a business can meet customer orders even during stock shortages.
- **Slotting:** The process of organising and categorising products within a warehouse to optimise picking efficiency, often by placing high-demand items closer to packing stations.
- **Stock Keeping Unit (SKU):** A unique identifier for each product in a warehouse, used to track and manage inventory.

- **SCM (Supply Chain Management):** The management of the entire flow of goods and services, from raw materials to the delivery of the final product to the customer, encompassing planning, sourcing, production, and logistics.
- **Third-Party Logistics (3PL):** Outsourcing logistics operations, such as warehousing, transportation, and distribution, to a third-party company to handle these services on behalf of a business.
- **Transit Time:** The time it takes for goods to be transported from the point of origin to their destination.
- **Transloading:** The process of transferring goods from one mode of transportation to another, typically between ocean freight and trucks or rail at a port.
- **Transportation Management System (TMS):** Software used to plan, execute, and optimise the transportation of goods, including route planning, carrier selection, and tracking shipments.
- **UCC (Uniform Commercial Code):** A comprehensive set of legal standards governing commercial transactions, including shipping contracts and warehouse receipts, to ensure uniformity across different states.
- **Uniform Freight Classification (UFC):** A standard used in North America to classify commodities for shipment based on factors like density, liability, and stowability.
- **Value-Added Services (VAS):** Additional services offered by logistics providers, such as labeling, packaging, and product customisation, beyond basic warehousing and transportation.
- **Vendor-Managed Inventory (VMI):** A supply chain practice where the supplier is responsible for managing and replenishing stock levels at the customer's warehouse or retail locations.
- **Warehouse Receipt:** A document issued by a warehouse to a shipper confirming the receipt and storage of goods, which can be used as collateral for financial transactions.
- **Warehouse Zone Picking:** A method of order picking where the warehouse is divided into zones, and pickers are responsible for retrieving items from their assigned zone only.
- **Wearable Technology:** Devices worn by warehouse workers, such as smart glasses or wrist-mounted scanners, to improve productivity and accuracy in picking and packing tasks.
- **Work-in-Progress (WIP):** Goods that are partially completed and still undergoing production or assembly processes, typically not yet ready for sale.
- **Yield Management:** The practice of adjusting prices and availability of inventory in real-time based on demand fluctuations to maximise profitability, often used in industries like airlines and hospitality.

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