Volume 1 | Issue 1 | MAY 2026

Designtree
Service Consultants Pvt Ltd
We design We care

INNOVATING

The Way The World Is Built

Stability is our core, and innovation is our reach. We bridge the gap between organic creativity and structured precision, transforming architectural complexity into clear, intelligent engineering solutions. Responsible by design and innovative by instinct, we prioritize purpose and performance, engineering today for a sustainable, high-impact tomorrow.

CORPORATE HEAD OFFICE

BENGALURU
64/9, Kembathalli Main Road
9th Phase, JP Nagar
Bengaluru - 560083. INDIA
T : +91 80 7199 5481
E : info@designtreeconsultants.com

BRANCHES

CHENNAI
10, 3rd Floor, G.J. Complex, 1st Main Road
CIT Nagar, Chennai - 600035
T : +91 44 2482 5397
E : chennai@designtreeconsultants.com

MUMBAI
B710, Kanakia Wall Street, Andheri Kurla Road
Chakala Andheri (East), Mumbai – 400093
T : +91 90046 16220
E : mumbai@designtreeconsultants.com

HYDERABAD
5A, 5th Floor, Vaishnavi Cymbol
Nanakramguda Financial District
Hyderabad - 500032
T : +91 70939 41222
E : hyderabad@designtreeconsultants.com

PUNE
904A, 9th Floor, City Tower, Boat Club Road
Bund Garden, Sangamvadi
Pune – 411001
T : +91 99008 26321
E : pune@designtreeconsultants.com

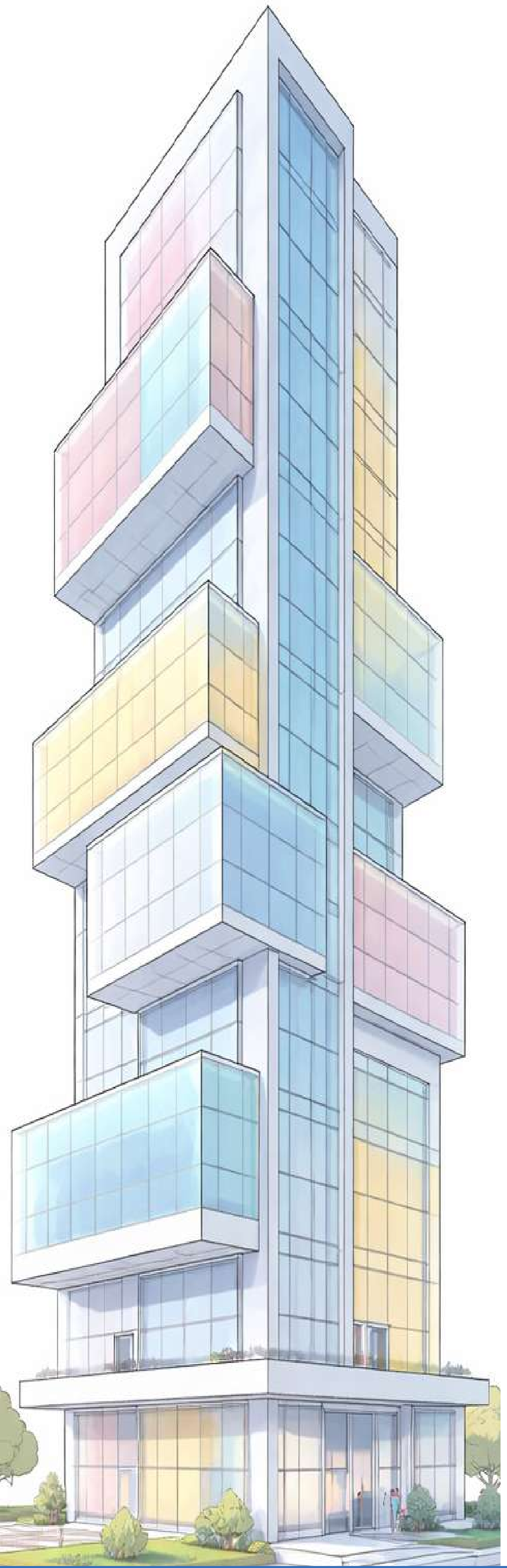
KOLKATA
6, 2nd Floor, Parkside Road
Manoharpukur Kalighat
Kolkata - 700026
T : +91 98317 80580
E : kolkata@designtreeconsultants.com

VIJAYAWADA
52-1/1-2A, 3rd Floor, Arka Plaza
Service Road Veterinary Colony
Vijayawada - 520008
T : +91 90108 48822
E : vijayawada@designtreeconsultants.com

Civil
Structures
Public Health
Fire Protection

Electrical
HVAC
Green Building
Infrastructure

Scan for website
https://www.designtreeconsultants.com/



Contents

Prologue

At DesignTree, we engineer what lasts-creating ecosystems where performance, sustainability, and purpose converge. Driven by innovation and grounded in engineering expertise, our work across diverse sectors reflects intent. An intent to innovate, to elevate standards, and to build for the future.

Like a deeply rooted tree, DesignTree stands firm-anchored in knowledge, defined by integrity, strengthened by structural insight and evidence-based practice. Our trunk reflects stability and strength. Our branches expand into innovation and multidisciplinary excellence. And every project we deliver becomes a leaf-symbolizing growth, collaboration, and continuous evolution.

Because at DesignTree, every outcome is not an end point it is progress.

In our culture, architecture and engineering have always been interconnected-balancing science with philosophy, precision with purpose. Design goes beyond numbers it demands clarity, carries responsibility, and outlines legacy. Each phase strengthens our foundation and elevates our vision-manifested in projects that exemplify expertise, validated rigor, and forward-thinking excellence.

INNOVATING is born from this very philosophy. It is not just a magazine it is our canopy of ideas. A platform where knowledge meets application, where experience meets curiosity, and where ideas are transformed into real-world impact. This edition brings together seasoned expertise and emerging voices, capturing the depth, complexity, the shifting paradigm of our profession and the people who drive it forward. Like a sacred tree that strengthens with every season, we continue to grow powered by collaboration, and inspired by the enduring legacy of Indian tradition.

In a rapidly changing world, engineering must lead with foresight, adaptability, and sustainability. And at the heart of it lies a simple truth: growth is interconnected, people drive organizations, organizations shape industries and industries build nations.

Because true excellence is never one-dimensional. It thrives when individuals grow beyond roles-into leaders, thinkers, creators, and contributors to society.

As we reflect on the journey of DesignTree, we see a similar spirit shaping our organization-and now, our Magazine. This magazine echoes that belief, where every idea contributes, every insight connects, and every story adds value This is not just a collection of articles.

It is a reflection of who we are.

And where we are going.

As you turn these pages, explore boldly, think critically, and take pride in the role you play in shaping the built environment.

From Strong Roots to Iconic Highrises

K.Srinivasa Reddy
Managing Director
DesignTree Service Consultants Pvt. Ltd.

Great journeys do not wait for certainty - they begin with belief. DesignTree was born from a simple yet powerful idea: when individuals come together with perseverance, dedication, and a shared purpose, they create something far greater than themselves. From the very beginning, DesignTree was never just about engineering; it was about a vision- bringing together disciplines that often worked apart and creating a space where Structural and MEPF engineering could think, design, and solve problems as one. Our goal was simple, to move beyond drawings and deliver engineering solutions that truly work in the real world.

Like a tree planted with conviction, DesignTree took root through discipline, integrity, and an unwavering commitment to excellence. What began with modest resources was driven by a determination and the desire to set a higher standard for engineering. In those early days, our focus was not on rapid expansion, but on building trust- giving every project our full involvement, every detail our attention, and every commitment our uncompromising focus on quality.

Over time, those strong roots grew deeper and our branches spread across India, touching cities and communities nationwide. From contributing to the construction of high-rise developments to engineering prestigious and complex projects across the country, our journey has been defined by a commitment to deliver solutions that stand today.

Instead of chasing growth, we chose to build trust first - project by project and relationship by relationship. What started as a small step evolved into the defining culture of DesignTree, where quality, ownership, and integrity guide how we grow, innovate, and deliver.

Yet, the true strength of DesignTree lies not only in the structures we design, but in the people who bring those achievements to life. The bond between employer and employee is built on respect, trust, and shared ambition which forms the foundation of our organization. I firmly believe the success of any company is reflected in the happiness, growth, and pride of its people.

Today, DesignTree stands as a symbol of reliability, technical excellence, and seamless engineering coordination. What once began as a founder's vision has grown into a thriving organization shaped by the collective passion, dedication, and commitment of its people.

At DesignTree, challenges are never barriers, they are catalysts that push us to think deeper, design smarter, and deliver beyond expectations. Our teams approach every project with a strong sense of ownership and confidence, believing wholeheartedly that this is our work, and together we will make it exceptional.

What truly makes us unique is the harmony between generations, the energy of young minds, the strength of experienced professionals, and the wisdom of senior mentors coming together to create a culture where knowledge flows freely and innovation thrives. Guided by your trust, we continue to evolve by adopting advanced technologies like BIM and delivering sustainable green building solutions that create safer, smarter built environments.

As we step into the next decade, DesignTree moves forward with a bold dream, embracing advanced digital tools, data-driven engineering, and sustainable practices to build resilient communities. Our purpose remains clear: to continue building an organization where talent is nurtured, ideas are empowered, and the next generation of leaders are prepared to carry this vision forward.

No meaningful journey is ever built alone. A note of gratitude to our partners, clients, and builders - thank you for trusting us with your vision and allowing DesignTree to be part of building it. From a small team of 10 to now 780 strong, your support has shaped our growth and strengthened our ability to serve you better.

To our friends and well-wishers -thank you for standing beside us through every triumph and every test. Above all, to our employees & their families, past and present -you are the heart of DesignTree.

To my family, for your unwavering belief & support. And to my constant companion - thank you for your quiet support and boundless patience, the true strength behind this journey.

The most exciting chapters are still ahead. Because in the end, a company's greatest legacy is not only the structures it builds, but the people it inspires, the values it upholds, and the future it helps create.

Now we are delighted to introduce Innovating, DesignTree's very own magazine - a platform where our team's ideas, insights, and experiences come alive, inspiring curiosity, collaboration, and a shared passion for creating smarter, safer, and more sustainable spaces. As you turn these pages, may they spark new ideas and open new possibilities.

B O Prasanna Kumar
Jt. Managing Director
DesignTree Service Consultants Pvt. Ltd.

DesignTree's vision is to create structures that are not only functional but also sustainable and aesthetically pleasing, with a focus on innovation, progress, and collective growth. Our portfolio includes notable projects such as, hospitals, hotels, commercial complexes, retails, malls and multiplexes, showcasing our expertise in diverse disciplines in structural and MEP engineering.

Architecture and engineering in our culture were never isolated practices; from the principles of VastuShastra to the craftsmanship of our heritage structures, design has always balanced science with philosophy, precision with purpose. Design is more than calculations and drawings; it is a legacy carried forward through generations of engineers, thinkers, and innovators. Each phase of growth has strengthened our technical foundation while expanding our vision towards the future. At DesignTree, we uphold this balance—where evidence leads decisions and experience refines execution.

This magazine is more than a publication; it is our canopy of shared ideas. It captures our journey, our technical insights, our milestones, and the people who nurture this ecosystem of excellence. Just as a sacred tree becomes stronger with every passing season, we continue to grow—guided by evidence, strengthened by collaboration, and inspired by the legacy of Indian tradition. Every project reflects accumulated expertise, rigorous validation, and a forward-thinking mindset. Our structures are not merely built for today; they are engineered for the generations that will use them tomorrow.

As I reflect on the journey of DesignTree, I see a similar spirit shaping our organization—and now, our Magazine. Each article reflects dedication, technical depth, and a commitment to continuous learning.

DesignTree's magazine is a testament to our commitment to sharing knowledge, insights, and best practices, aiming to elevate professional standards and foster dialogue within the industry. Through this magazine, we aim to foster dialogue, share insights, and elevate professional standards across our organization. As we turn these pages, may we remember that like a sacred tree, sustained growth requires strong roots, shared strength, and collective purpose. What strongly believe in our design and care for clients.

B E Pruthviraj
Director
DesignTree Service Consultants Pvt. Ltd.

Eighteen years ago, DesignTree began with a simple yet powerful idea — to create work that is thoughtful, meaningful, and enduring. What started as a vision gradually evolved into a journey shaped by passion, perseverance, and an unwavering belief in the power of design.

Over the years, DesignTree has grown not just in scale, but in purpose. Each project we have undertaken, each challenge we have embraced, and each milestone we have celebrated has contributed to the identity we proudly hold today. Our journey has been defined by learning, collaboration, innovation, and the continuous pursuit of excellence.

None of this would have been possible without the remarkable people who have walked this path with us. To our dedicated team — your creativity, commitment, and relentless effort have been the true driving force behind DesignTree's growth. You have transformed ideas into reality and challenges into opportunities.

To our clients and partners, thank you for placing your trust in us and allowing us to be part of your vision. Your confidence has inspired us to push boundaries, think differently, and constantly strive to deliver our very best.

And to everyone who has been a part of this journey over the past eighteen years — employees, collaborators, mentors, and well-wishers — your support has helped shape the story of DesignTree in ways that words cannot fully express.

As we pause to celebrate this milestone, we also look ahead with renewed energy and ambition. The world continues to evolve, and so will we — embracing new ideas, exploring new possibilities, and continuing to create work that reflects our values and aspirations.

As we celebrate this milestone, it also gives me great pleasure to present our commemorative magazine. This edition captures glimpses of our journey — the milestones we have achieved, the projects that have defined us, and the people whose contributions have shaped DesignTree into what it is today. It stands as a reflection of our collective efforts and the spirit that continues to drive us forward.

Eighteen years is not just a measure of time; it is a reflection of shared dreams, collective effort, and enduring relationships.

The journey continues...

B Manjunath
Director
DesignTree Service Consultants Pvt. Ltd.

As DesignTree Service Consultants Pvt. completes 18 years of its journey, it is a moment of immense pride and reflection for all of us who have been part of this remarkable story. What began as a bold vision to deliver high-quality structural and MEP engineering solutions has grown into a trusted consulting practice serving some of the most respected developers and corporate clients across India.

Over the years, we have had the privilege of contributing to the creation of diverse and complex developments—from large residential communities and IT parks to hospitals, hotels, malls, data centers and industrial facilities. Each project represents more than just engineering design; it represents collaboration, innovation, and the collective commitment of our team to build infrastructure that is safe, efficient, and future-ready.

The built environment is undergoing rapid transformation. Digital engineering, BIM-led collaboration, sustainable design practices, and integrated project delivery are redefining how projects are conceived and executed. At DesignTree, we see these changes as opportunities to push boundaries, embrace new technologies, and continuously elevate the value we deliver to our clients.

Our growth across multiple cities including Bangalore, Hyderabad, Chennai, Mumbai, Pune, and Kolkata and so on is a reflection of the trust our clients place in our capabilities and the dedication of our talented professionals who bring passion and precision to every project.

As we celebrate this milestone of 18 years, we also look ahead with renewed purpose. Our vision remains to be a forward-thinking engineering partner—one that combines experience, innovation, and integrity to help shape the evolving skylines and infrastructure of our country.

I extend my heartfelt gratitude to our clients, partners, and every member of the DesignTree family who have been instrumental in this journey. Together, we will continue to design, engineer, and build a better future.

DesignTree Pledge

In the world of engineering, progress is rarely the result of a single "eureka" moment. Instead, it is the product of sustained technical rigor, the restless exchange of ideas, and the strength of the professional communities that uphold industry standards.

At DesignTree, we have long maintained that our responsibility does not end at the edge of a project site. True engineering excellence requires a deep commitment to the "engineering ecosystem"- the network of institutions, regulators, and peers that define how the world is built.

Engineering cannot survive in a silo. The modern built environment is a complex puzzle of safety, sustainability, and innovation. Solving it requires a bridge between individual expertise and institutional governance.

For years, DesignTree has moved beyond being a mere practitioner to becoming an active contributor. Our involvement in industry bodies is not a corporate formality; it is a vital part of our professional DNA.

DesignTree is proud to reinforce its long-standing support for the organizations that serve as the backbone of the Indian engineering landscape. We stand firmly alongside:

- *ACCE(I): Association of Consulting Civil Engineers (India), Bengaluru*
- *ICI: Indian Concrete Institute, Bengaluru Centre*
- *KPCEA-SC: Karnataka Professional Civil Engineers Act – Steering Consortium*
- *IPA: Indian Plumbing Association*
- *FSAI: Fire and Security Association of India*
- *ELECRAMA: The global interface for the power sector*
- *ISHRAE: Indian Society of Heating, Refrigerating and Air Conditioning Engineers*

These bodies are the crucibles where safety codes are refined, new technologies are vetted, and the next generation of engineers is mentored.

As we face an era defined by climate resilience, rapid digitalization, and evolving material science, the role of professional networks has become more critical than ever. Knowledge must circulate faster, and standards must be more robust.

Our commitment is simple but firm:

1. *To Participate: We will remain at the table where standards are shaped and policies are debated.*
2. *To Contribute: We will share our technical insights to help the entire fraternity move forward.*
3. *To Advocate: We will champion responsible, performance-based design that prioritizes long-term safety over short-term ease.*

At the end of the day, the future of the built environment won't just be determined by the buildings we design, but by the professional culture we cultivate. DesignTree is dedicated to a future defined by accountability, collaboration, and shared purpose.

LEADERSHIP GALLERY

Sripada Mitra
Executive Director
Our Mission & Vision is to deliver technically sound, cost-effective, and safe engineering designs that exceed client expectations. And to be a globally trusted engineering partner known for innovation and sustainable engineering practices.

Mithun K. Reddy
Executive Director
For too long, the construction industry has treated structure and MEPF as separate conversations - one defined by static load, the other by dynamic flow. At DesignTree we speak both languages fluently. We don't just engineer buildings, we engineer total performance.

Rahul Manjunath
Executive Director
The future of building services goes beyond systems that simply work. Powered by data, smart technology, and automation, it is evolving from hidden infrastructure into the intelligent backbone of future-ready buildings—creating environments that are smarter, more efficient, and sustainable for the next generation.

Prashanth Gururaj
Associate Director
Engineering service consultant shoul d adapt Golden triangle emphasising on **Technology, Project and Client.** Being successful means finding the perfect recipe between each other.

Kartick V Bhat
Associate Director
Service engineering is the practical application of science, mathematics, and creativity to design and build solutions for complex problems. It involves creating, testing, and improving various structures, machines and systems to increase efficiency and safety.

Srinivas Rao Bolimuntha
Associate Director
Structural engineering is a specialized branch of civil engineering focused on designing, analyzing, and constructing stable, safe, and durable structures like buildings, bridges, and towers. These engineers ensure structures can withstand various loads—including gravity, wind, and earthquakes—by calculating appropriate material strengths, such as steel or concrete. Their work involves close collaboration with architects to ensure projects are safe, compliant with building codes

B N Chandrashekar
Associate Director
Quality Management System (QMS) in the construction industry is essential to ensure that projects meet specified standards, safety requirements, and client expectations. It involves systematic planning, monitoring, and control of materials, workmanship, and processes at every stage of the project lifecycle. Effective quality management minimizes defects, reduces rework, and enhances durability and performance of structures. By adopting strong QA/QC practices, documentation systems, and continuous improvement approaches, teams can deliver reliable, cost-effective, and sustainable projects.

Groundwater Management with Peripheral Bore wells in Tall Buildings

B N Chandrashekar
Associate Director - Technical & BD

Highrise buildings with deep basements in highgroundwater areas are vulnerable to uplift pressure, seepage, reduced soil bearing capacity, and durability issues. A subsoil drainage system with peripheral bore wells helps control groundwater by lowering the water table and relieving hydrostatic pressure around foundations. Widely used in cities such as Bengaluru, Mumbai, Chennai, and the National Capital Region, it ensures safer basements and reduces long-term maintenance.

Case Study Reference (Bengaluru)

A highrise building completed in 2015–16 experienced basement flooding in 2019 due to intense rainfall and groundwater movement through subsurface rock fractures identified by geophysical investigations. The issue was resolved by installing vertical drainage bore wells within and around the tower foot print to relieve groundwater pressure.

Overview of Subsoil Water Issues in Buildings

Tall buildings with deep basements and underground facilities are highly sensitive to subsoil water conditions. Groundwater, perched aquifers, and seepage from nearby lakes or drains can increase hydrostatic pressure, cause seepage, weaken soil, and threaten structural safety and durability.

Key Problems Caused by Poor Subsoil Drainage

Poor subsoil drainage in highrise buildings can cause hydrostatic uplift pressure on basements and raft foundations, leading to instability, flotation, and water seepage through joints and retaining walls. Excess groundwater weakens soil, reducing bearing capacity and increasing the risk of differential settlement. These problems are more critical in tall buildings due to deeper excavations, large basement areas, heavy loads, and sensitive underground facilities such as parking and utility rooms.

Objective of Providing Subsoil Drainage with Bore Wells

The primary objective of subsoil drainage with bore wells is to control groundwater around foundations and ensure the stability of buildings with deep basements. Lowering the groundwater level reduces hydrostatic uplift pressure on raft foundations and basement slabs, preventing flotation and seepage. It also helps maintain soil bearing capacity, protects structural durability, and keeps basement areas such as lift pits, electrical rooms, and parking spaces dry and functional.

Case Study of Project 1 at Bengaluru

Groundwater Relief Measures Implemented After identification of fracture in Subsurface Rock Layers beneath the foundation

Project details

Residential building comprising of 2 buildings, Building 1 with of Tower 1 & Tower 2 and Building 2 with Tower 3 & Tower 4 having 2 Basement + Ground floor + 25 upper floors & Terrace floor, is designed by us based on the approved architectural plans.

Description of Building

The proposed building consists of four towers namely 1, 2, 3 & 4 with two common basements for parking

Floors	Details
Lower & Upper Basement & Ground Floor	Parking, Utilities & Clubhouse
1st to 25th floor	Residential units
Terrace floor	Staircase head room, lift machine room & Overhead tank

Soil Report

The site has a non-uniform topsoil layer (0.2–0.65 m) underlain by laterite up to about 1.5–3.5 m, which is very loose at some borehole locations. Disintegrated rock occurs below this layer, with medium rock encountered between 3.2 m and 11.0 m depth. Groundwater was not observed during exploration, though a perched water table may form in the rainy season, and foundations are recommended on laterite or disintegrated rock with settlements expected within 25 mm.

Bore Hole Locations: The bore hole locations are mentioned in the below page,

Foundation

Foundations are designed based on the geotechnical investigation report conducted by F.S. Engineers (Report No. 5866 dated 11 January 2014). The soil bearing capacity is considered as 50 t/m², which is adequate to safely transfer all vertical and horizontal loads to the underlying soil. Depending on the soil conditions, either individual footings or a raft foundation is adopted. Considering the presence of basements and possible perched water during the rainy season, waterproofing is proposed for the foundations, grade slab, and retaining walls. As the soil report indicates no groundwater at foundation level, the grade slab has not been designed for uplift pressure.

Waterproofing system recommended Basements, Drains, Sumps, Ramps & Trenches, STP, Lift Pits

Providing and laying 2mm thick, SBS Modified, pre-fabricated polyester surfaced single layer self-adhesive polyplus waterproofing and protection membrane with 250 gsm needle punctured polyester matt on top.

Alternative

Providing and fixing Proofex Engage a 4mm thick Pre-applied HDPE waterproofing membrane which mechanically bonds to poured concrete for Raft slabs and retaining wall. Pre-applied HDPE Proofex Engage waterproofing membrane.

Subsoil drainage system is being suggested as per the drawing below in order to address the perched water issues during monsoon.

Issues

Post monsoon in the year 2019, Client invited us to visit the basement. This was requested as dampness and water seepage was observed in the retaining wall and slabs both in the upper and lower level basement area .

The lower basement was flooded with water, there was panic in the resident's as the slab is not designed for taking the water pressure and the basement was not conducive for parking.

Observations

- Water is oozing through retaining walls in both basements, with higher leakage and dampness in the lower basement.
- Pressure relief cores in the lower basement are partially reducing water pressure.
- Cracks are observed in retaining walls and roof slabs, with seepage occurring through construction joints.
- Flexible polyurethane grouting is effective, while cement grouting has not been successful; water is migrating from treated to untreated areas.
- During monsoon periods, basement flooding occurs due to increased groundwater ingress.

Root cause

- Post site inspection revealed that no subsoil drainage system has been provided for the basements.
- A robust water proofing system is absent; only crystalline admixture (local brand) has been used in the retaining walls.
- The justification provided was that ground water was not indicated in the soil investigation report.
- The crystalline waterproofing alone is inadequate for a two-level basement.
- Multiple injection grouting attempts have been carried out to control leakage; however, seepage continues and the basement remains flooded.

Subsoil Drainage system drawing

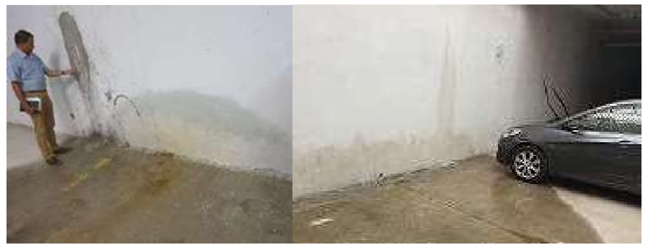


Fig 1: Water oozing out from the retaining walls

Fig 2: Water oozing out from the retaining walls

Recommendation

Pursuant to the reasons stated above, following are the recommendations:

1. Removal of back filling on the positive side of the retaining wall .
2. Carrying out the injection grouting at the construction joints and intersection of raft of and retaining wall.
3. Provide 1.5mm self-adhesive system (SBS based) on the positive side with protection board of 3-4mm thick
4. Back filling to cover the retaining wall.
5. Provide surface drain along with periphery of the retaining wall to navigate the water to the collection pit.
6. Provide bore wells at suggested intervals to help to mediate release of water pressure beneath the grade slab/foundations as the grade slab is not designed for uplift pressure.

To address water seepage and ingress, a feasibility study was conducted to understand site hydrogeology and maintain groundwater below the basement level. A geophysical survey by M/s Deep Water Explorers identified six borewell locations to help lower the groundwater table. Based on recommendations from groundwater consultant C. S. Ramasesha, garland drains connected to bore wells were proposed to collect subsoil water and discharge it into the main drainage system.

Geophysical survey carried out at Project 1

Objectives and scope of the studies

The survey assessed subsurface geology and aquifer conditions using the PQWT-TC500 instrument to generate two-dimensional subsurface images through topographical profiling. Eight profiles were carried out at 5-m intervals with depth exploration up to 500 m to identify suitable locations for detailed investigation at 1-m intervals.

Fig 3: Under water profiles Geophysical automatic mapping underground water detector PQWT-TC500

Conclusions of geophysical report

- The site is underlain by granitic gneiss with an overburden thickness of about 6–12 m, resting on hard and compact rock.
- Seven geophysical profiles (724–730) were carried out at 5 m intervals to generate a 2D subsurface image and identify suitable locations for groundwater abstraction and dewatering during monsoon periods.
- Two distinct groundwater tables were identified, including a perched water table at a depth of about 18–21 m, mainly observed during the rainy season or when nearby tanks contain water.
- The second basement floor level appears to remain saturated by at least one meter.
- An existing bore well in the southeast corner, reportedly drilled to 360 m, is currently filled with debris and not yielding water.
- The upper aquifer up to about 200 m depth appears to be partially depleted due to over-extraction in parts of Bengaluru.
- Rock fractures in some areas allow ground water to seep into the basement.

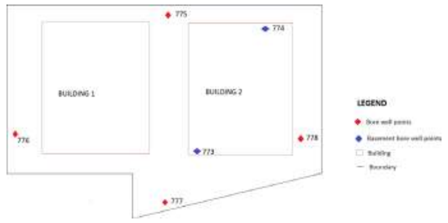


Fig 4: Deep well locations

Further detailed investigations at 1 m intervals are recommended to determine precise locations for additional bore wells.

Further to the earlier investigations carried out by the client on 14/11/2019 six profiles were carried out at the locations as detailed below.

Table 1: Soil Profiles / Bore Well Details

Sl No	Description	Profile 773 Node:13	Profile 774 Node: 13	Profile 775 Node: 5
1	Location	South South West of the property.	North East corner of the property	North corner of the property
2	Depth to be drilled (m)	250m	270m	260m
3	Expected Casing pipe to be installed (m)	39-43m	39-43m	39-43m
4	Expected Yield (liters per second) for estimation purposes	2	2	2
5	Expected fracture in meters	240m*	50m*, 60m*, 110m, 130m	70m, 100m, 120m, 140m
6	Drilling ought to be carried out under supervision of an experienced drilling Engineer/ geologist. The well should be taken over from the driller only after confirming the depth & the water is clear & free form sediments & suspended particles			
7	It is recommended to carry out a yield test on the bore wells to determine the right type of pumping device & no of hours of pumping hours per day as per the stress strain relationship of the environment			
8	It is strongly recommended to harvest rain water.			

Recommendations as per ground water consultants

- It is recommended to drill six identified borewell locations, marked on site, under supervision.
- Lithological samples should be collected during drilling.
- The bore wells should subsequently be pump tested using Step Drawdown Test (STD) and Aquifer Performance Test (APT) to evaluate their performance.

Robo equipment used for drilling the borewell inside the tower building

A robo compact bore well machine is an advanced, automated drilling rig for water wells, using hydraulic power, sensors, and sometimes a "robo spider" design for manoeuvrability, allowing for faster, precise drilling with minimal manual labor, especially in tight or congested urban spaces, featuring remote operation, real-time monitoring, and automated drill rod handling for efficiency and safety, These machines excel in various terrains, reduce environmental impact, and offer precise water depth location, making them ideal for modern, space-constrained drilling needs.

Typical Dimensions (Approximate)

Width: Around 6 feet.
Length: Around 13 feet.
Height: Around 11 feet.
Advanced Robo Rigs: depth often reaching 1000+ feet (300+ meters).

Fig 5: Water level monitoring

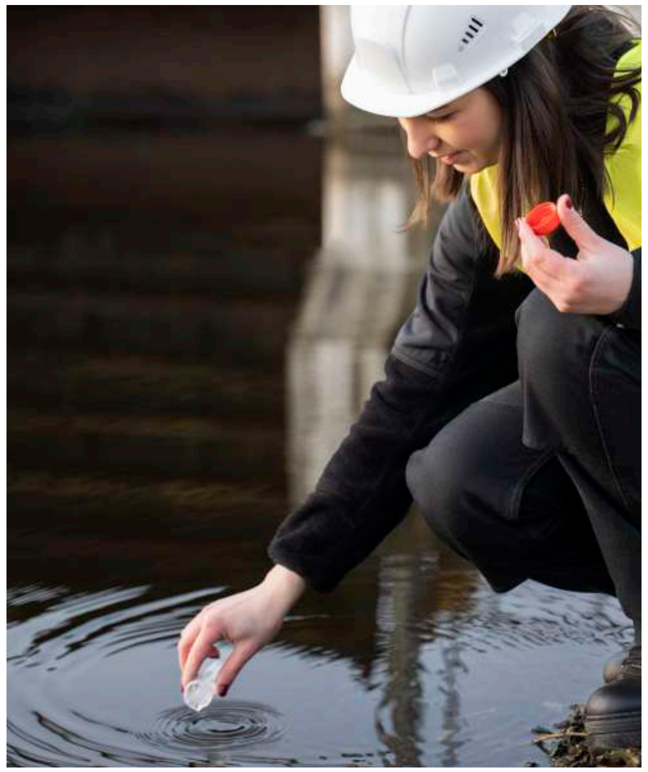
Fig 6: Basement in dry condition & the residents are happy as the basement remains dry.

- Post bore well & monitoring the pump activity, most of the basement areas remain dry.
- Following the site photos & these bore well water being used for domestic purpose, in case of excess water the same is diverted to ground recharge pit near to the entrance of the building. Conclusion:
- Subsoil drainage systems with peripheral boreholes are vital for managing groundwater in tall building foundations. Their design and implementation require careful consideration of local soil conditions

Conclusion

Subsoil drainage systems with peripheral bore-holes are vital for managing groundwater in tall building foundations. Their design and implementation require careful consideration of local soil conditions, groundwater levels, and structural requirements. On-going research and case studies continue to inform best practices, ensuring these systems contribute to the safety and longevity of tall buildings.

1. Providing the bore holes inside the tower & outside tower foot print helped in keeping the basement dry for most part the year.
2. Bore wells helped to keep the below ground level [foundations, basement] area dry & grade slab will not be affected with uplift pressure.
3. Continuous monitoring and maintenance of the bore well is the key factor.
4. Residents are comfortable to use the bore well water successfully and they are happy as the basement remains dry for most part of the year.
5. For future projects on rocky strata, advisable to get the geophysical survey done in line with IS 1892 -2021, which can reveal minute details of the strata below in addition to the geotechnical investigation.



Overstrength in Seismic Design Interpreting the provisions in revised seismic codes through Load-Path Behaviour

Sagar Dhamdherex
Technical Director - Structure

Overstrength as a Structural Reality
Overstrength has always existed in structures; what has changed under the revised Indian seismic provisions is that it is now being explicitly enforced in design. In practice, it is neither optional nor artificial. It is a direct consequence of allowing structures to respond inelastically.

Linear elastic analysis and design is carried out using partial safety factors for materials and idealised stiffness. Once yielding occurs, members develop their real sectional capacity, which is invariably higher than the design values assumed in analysis. This gap is created by material overstrength, strain hardening, slab participation, design margin, and redistribution within redundant systems.

Once ductile behaviour is assumed, overstrength follows automatically. Overstrength is the bridge between intended ductile behaviour and the protection of elements / actions that must remain essentially elastic. These actions / elements must remain elastic till the mechanism level i.e., till the point where ductile elements reach their plastic capacity. In other words, brittle actions must not fail, before ductile actions reach their plastic capacity.

Plane-Frame Analogy
Consider a regular two-dimensional moment-resisting frame subjected to lateral earthquake loading. Elastic analysis produces a base shear **Ve** and corresponding internal force diagrams.

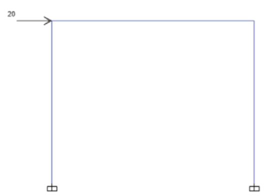


Fig 1: Geometry and Loading

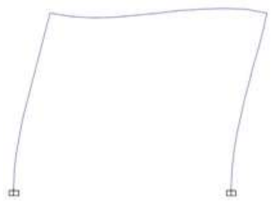


Fig 2: Deflected shape at mechanism level

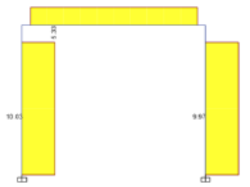


Fig 3: Shear force diagram

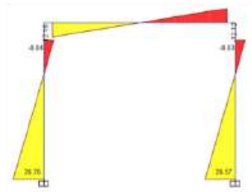


Fig 4: Bending moment diagram

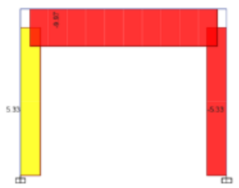


Fig 5: Axial force diagram

But earthquake demand does not stop at this elastic capacity level, it will keep increasing till structure reaches its real strength level. As lateral deformation increases, flexural yielding initiates at beam ends and spreads until a sway mechanism forms. The critical point is not first yield, but the development of full plastic moment capacity at the intended hinge locations.

At this stage, the internal forces in the frame, bending moment, shear force and axial force seen in Figures 3, 4 & 5 above predicted by elastic analysis, will exceed these values, at mechanism level. Beam end moments reach their real plastic values, typically 1.5–1.8 times the design moment. Correspondingly, beam shear, column shear, column axial force, and joint forces increase in proportion.

The base shear associated with this force state is:
Vy = Ω . Ve

where Omega Ω reflects the ratio of real flexural strength to design flexural strength of the yielding members. This increase is simply the equilibrium force state associated with the mobilisation of real strength of the overall structural system.

Overstrength in IS 1893
IS 1893 (Part 1): 2025 defines Overstrength Base Shear as:

"…the horizontal shear force induced at the base of the structure when it sustains desirable ductile inelastic actions under the action of the design earthquake ground shaking…"

This definition ties overstrength to ductile inelastic action. Overstrength base shear corresponds to the force level associated with the mobilisation of real flexural capacity in the lateral system.

The code deliberately refrains from prescribing how this force is to be distributed to individual members. That responsibility is transferred to the designer through system selection, detailing philosophy, and identification of force-controlled actions.

Deformation-Controlled and Force-Controlled Behaviour
Ductile seismic design relies on a clear hierarchy of behaviour. Flexural yielding of beams, shear walls, and properly detailed coupling beams is intentionally permitted. These are deformation-controlled actions, governed by rotation and curvature capacity rather than force limits.

Whereas, actions such as beam shear, column shear, column axial force, joint shear, wall shear, boundary-element axial force associated with overturning, collector forces, brittle coupling-beam actions, and foundation forces must remain essentially elastic. Brittle failure is prohibited. These are force-controlled actions.

At the section level, flexure, shear and axial force are inseparable. However, seismic design distinguishes between ductile limit states (yielding and rotation) and brittle limit states (shear failure, axial crushing, bar buckling, anchorage failure or load-path rupture). Overstrength applies to the latter, not the former. This distinction is consistent with international practice, including ASCE, and covers all capacity-design provisions.

It is important to note that overstrength-level forces represent a verification of force-controlled actions and are not intended to be included indiscriminately in general design load combinations within analysis software, in order to avoid the risk of double counting.

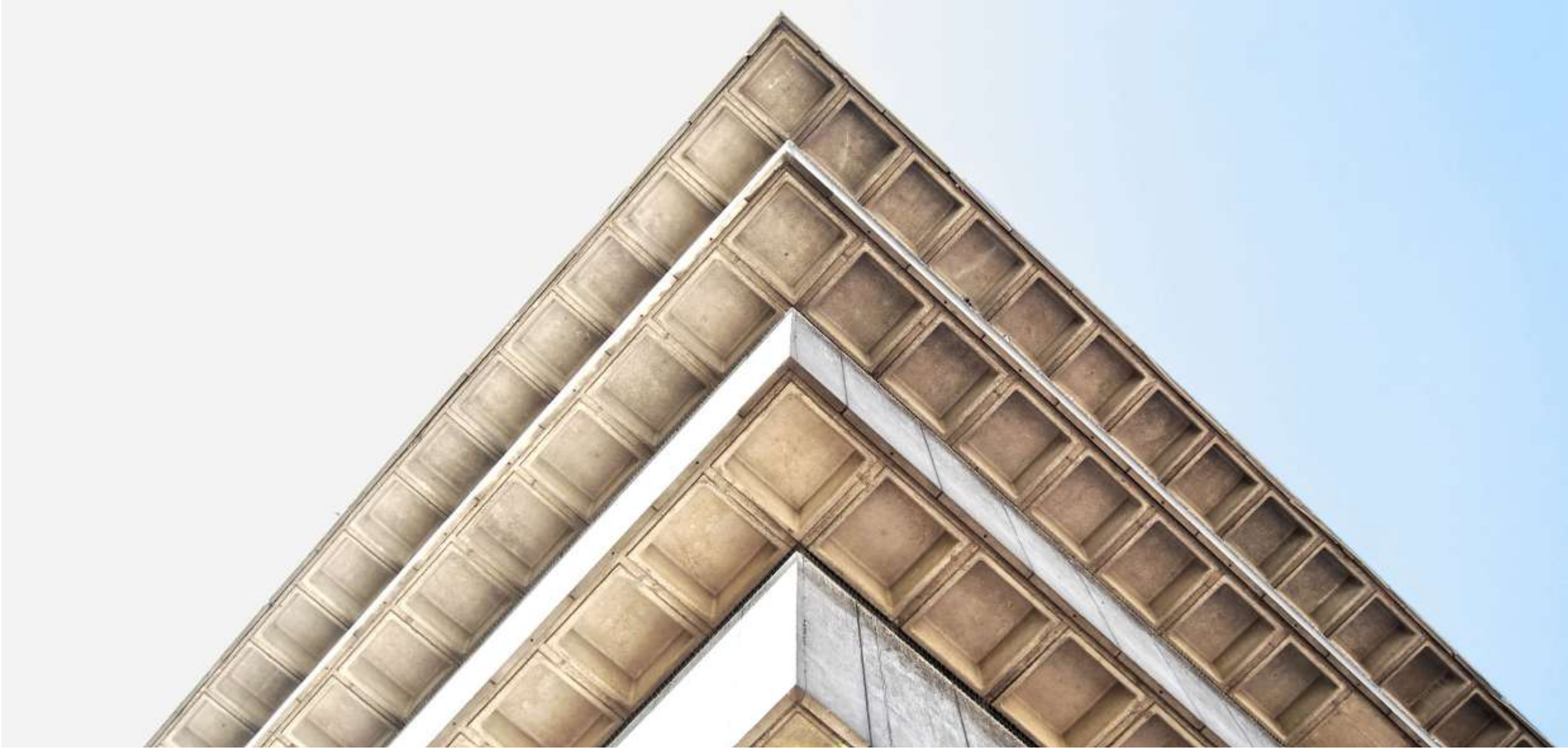
Application to Regular Buildings
IS 13920-2025 (draft) permits buildings with moment-resisting frames and/or shear walls to designate a lateral force-resisting system (LFRS) that carries the seismic demand. Other members are treated as gravity systems governed by deformation compatibility.

This establishes a practical separation between:
- force-controlled load paths within the LFRS, and
- deformation-controlled members elsewhere.

Within the LFRS, overstrength governs the design of columns, joints, shear walls, coupling beams, collectors, and foundations. Outside the LFRS, members are not exempt from seismic effects, but their design is governed by drift compatibility rather than force equilibrium. This approach aligns with international practice, where overstrength is applied selectively to force-controlled actions in the seismic load path. Table 1 below summarises a rational interpretation of deformation-controlled and force-controlled actions in real buildings, and the corresponding application of overstrength, consistent with load-path behaviour rather than blanket amplification.

Table 1: Application of Overstrength in Real Buildings – Element-wise Interpretation

Element	System Role	Deformation-Controlled Actions (DC)	Force-Controlled Actions (FC)	Overstrength Factor for FC(Ω)	Remarks
Beams	LFRS	Flexure	Shear	NA	Beam shear to be designed for capacity sway shear corresponding to probable plastic moments
Columns	LFRS	Flexure	Shear, axial force, joint forces	2.0	-
Shear Walls	LFRS	Flexure	In-plane shear, boundary-element axial force, anchorage	2.0 - 3.0	-
Beam-Column, beam-wall Joints	LFRS	—	Joint shear, anchorage, bond	2.0	-
Coupling Beams	LFRS	Flexure	Shear	NA	Intended to yield and dissipate energy; capacity-based shear design governs
Collectors / Drag Members	Force transfer path	—	Axial force, shear, connection forces	2.0	-
Transfer Girders / Plates	Force transfer path	—	Flexure, shear, axial force	2.0	-
Floating Columns	Gravity	—	NA (compatibility governed)	NA	Column designed for gravity + deformation compatibility
Gravity Columns (non-LFRS)	Gravity	—	NA (compatibility governed)	NA	Designed for gravity, drift compatibility, and second-order effects only
Foundations–LFRS Columns	LFRS	—	Bearing, uplift, shear, anchorage	2.0	Safely transmit overstrength-level column forces
Foundations–LFRS Shear Walls	LFRS	—	Bearing, sliding, overturning, anchorage	Same as walls	Safely transmit overstrength-level wall forces
Foundations–Gravity Columns	Gravity	—	NA (compatibility governed)	NA	-



Overstrength load combination:
DL + LL +/- Ω EL

While the overstrength level checks are applicable to force-controlled actions, clause 14.4.4 of IS1893-part 5, 2025, clarifies that the resulting demands need not exceed those obtained from equilibrium with overstrength plastic hinges in adjoining elements.

Collectors, Transfer Girders, and Floating Columns

Collectors, transfer girders or plates, and similar elements exist to maintain continuity of the seismic load path where geometry or system layout requires force redirection. They are not intended to dissipate energy and are therefore force-controlled by nature.

When ductile elements in the lateral system develop their real plastic capacities, the forces transmitted through collectors and transfer elements are governed by mechanism-level equilibrium rather than elastic analysis results. This behaviour is most evident at transfer levels supporting floating columns. While the floating column itself is governed primarily by gravity load combined with deformation compatibility and second-order effects, the supporting transfer girder or plate lies directly on the seismic force path. The forces delivered to it reflect the overstrength of the ductile system above and must be resisted without brittle failure.

Overstrength and the Limits of Codal Prescription

In conclusion, the revised Indian seismic framework recognises overstrength explicitly but does not define a clear hierarchy between deformation-controlled behaviour and force-controlled actions. Overstrength is specified for columns in general terms, without differentiation between flexure, shear, and axial force. For shear walls, the provisions largely address in-plane shear strength, with limited guidance on the treatment of axial forces in boundary elements and anchorage forces that arise from overturning equilibrium. In the absence of explicit force-path differentiation, designers are left to apply engineering judgment. Overstrength is an unavoidable consequence of ductile behaviour and real material strength. The challenge lies in applying it selectively and purposefully, aligned with load paths and failure modes. Bridging this gap between codal prescription and informed design judgment will be crucial in Indian seismic design practice.

Behind the Bars Fine Tune the Chemistry of Secondary Steel PART-01

Dr Arpitha D
DMSE - Structure

Spotlight: the truth about secondary steel
Secondary steel is at the heart of India's infrastructure boom and at the heart of myths. This article cuts through those misconceptions, unpacking the metallurgy and science of scrap-based steel. The message is clear: when chemistry is precisely controlled, recycled steel isn't "secondary" at all. It's simply steel which is new, reliable, and made through a smarter route.

Steel performance is dictated by its chemistry and microstructure. While primary ore-based routes ensure tight control over impurities, secondary scrap-based steel often carries residual tramp elements (S, P, Cu, Sn, As, Sb). If not controlled, these elements embrittle grain boundaries, accelerate localized corrosion, and reduce mechanical performance.

Yet key challenges persist. With today's refining technologies like Induction Furnaces, Electric Arc Furnace (EAFs), ladle refining Furnace (LRFs,) vacuum degassing, and automated chemistry monitoring, secondary steel can consistently achieve and even surpass BIS/ASTM requirements. Strength enhancement in reinforcing bars is primarily achieved through three routes: cold working, thermo-mechanical treatment (TMT), and micro-alloying. Each route tailors the steel's microstructure to deliver the high strength, ductility, and durability demanded by modern construction. Secondary steel drives sustainability, recycled from scrap, it slashes energy use and carbon emissions, conserves natural resources, and keeps materials in a circular loop. Efficient, eco-friendly, and future-ready.

The article underscores that "secondary steel" has no metallurgical or code-based definition BIS and global standards do not recognise the term. What matters is compliance with certified chemical and mechanical requirements, not the production route. With strong scrap supply chains, energy-efficient processes, and robust quality-control systems, India's secondary steel sector is set for rapid growth as infrastructure development accelerates. This Spotlight cuts through the noise, the real story of what happens when metal is reborn, and why knowing the truth behind secondary steel matters more than ever.

Iron (Fe) has long been the backbone of industrial progress due to its abundance, strength, and ease of fabrication. Yet, its softness and high corrosion susceptibility limit its standalone performance. These shortcomings sparked one of humanity's most significant material breakthroughs, led to the development of iron-based alloys.

Alloys are engineered mixes of two or more elements, at least one metal designed to boost strength, hardness, ductility, and corrosion resistance. Steel stands as the most significant of these alloys: a refined blend of iron and carbon, often enhanced with chromium, nickel, or manganese. With controlled composition and microstructure, steel delivers superior strength, toughness, and durability, far outperforming pure iron.

Steel represents a perfect fusion of science and practicality. To summarise, the key attributes of reinforcement necessary for designing sound and durable reinforced concrete (RC) structures include strong bonding with concrete, adequate strength, sufficient ductility, and reliable resistance to corrosion.

Properly recycled scrap does not become "secondary steel." Once scrap is collected, sorted, and melted in an EAF/IF with proper refining, impurity control, carbon adjustment, and alloying, it emerges as new steel that meets BIS requirements. Metallurgically, it is identical to primary steel, and its quality is determined by process control not by the scrap route. Therefore, recycled steel should be treated as new, certified steel, not inferior or "secondary" steel.

In steelmaking, "secondary steel" doesn't exist but only certified steel does.

The term "*secondary steel*" was never born in a furnace, it was coined on construction sites. It appears in no BIS standard, no code of practice, and no steelmaking manual. Even the Joint Plant Committee (JPC), the government's official steel databank, does not label anyone as a "primary" producer; it only maintains producer lists for statistics, not classifications.

Civil engineers coined the term "secondary steel" to describe older, inconsistent materials, not because the steel industry formally recognizes any such category. Modern reality? Steel has only one identity: the grade it meets and the chemistry it delivers.

Experts emphasize that secondary steel should be judged on proven performance, not outdated perceptions. With modern testing facilities and updated specifications, acceptance must rely on verified results not origin or old beliefs. Adopting advanced evaluation methods ensures decisions that are accurate, reliable, and future-ready across industries.

Future Outlook: How the Secondary Steel Sector Will Drive India's Growth

India's economic growth will increasingly rely on the Secondary Steel sector, driven by urbanization and infrastructure demand. Agile, cost-efficient secondary producers, supported by scrap recycling, energy-efficient technologies, and green steel initiatives, are well-positioned to lead. Government support, quality standards, and BIS compliance will boost competitiveness, making Secondary Steel a key driver of jobs, sustainability, and India's global manufacturing ambitions.

Beyond the Misconceptions
Modern secondary steel, refined with advanced processes and continuous casting, delivers BIS/ISO-certified grades like Fe500, Fe550, and Fe500D with uniform strength and ductility. Performance depends on grade and process, not whether steel is primary or secondary, despite outdated myths.

However, requirements as per IS 13920 -2016 cl 5.3.1

- Steel grade of Fe 500 and Fe 550, that is; high strength deformed steel bars produced by thermo-mechanical treatment process having elongation more than 14.5% and conforming to IS 1786.

- The actual 0.2% proof strength (A) of steel bars based on tensile test must not exceed their characteristics 0.2% proof strength(C) by more than 20 % i.e A/C < 1.2
- The ratio of the actual ultimate strength (B) to the actual 0.2% proof strength(A) shall be at least 1.15, i.e B/A >1.15

The Bureau of Indian Standards (BIS) specifies the required chemical composition, mechanical properties, and dimensional tolerances for billets, blooms, slabs, plates, and other secondary steel products. The Ministry of Steel (MoS) further outlines guidelines indicating where and how secondary steel may be used across various infrastructure sectors. When secondary steel meets BIS standards and complies with MoS and IR norms, it is fully approved for use in infrastructure projects, except in areas where specific restrictions apply, such as certain critical bridge components.

When alloying goes wrong, corrosion goes strong

In steel, chemistry is destiny. Shift the chemistry, and steel loses its harmony: ferrite softens, pearlite thins, and inclusions rise. That's when corrosion finds the cracks and turns them into chaos. When the alloy isn't balanced a slight spike in impurities or a slip in composition can turn a strong metal into a corrosion hotspot.

Alloys and their components

- Steel – Iron (Fe) + Carbon (C) and sometimes other elements like manganese, chromium, or nickel.
- Bronze – Copper (Cu) + Tin (Sn).
- Brass – Copper (Cu) + Zinc (Zn).
- Stainless Steel – Iron (Fe) + Chromium (Cr) + Nickel (Ni).

Secondary steel, made from recycled scrap, contains both beneficial alloying elements (C, Mn, Cr, Ni, Mo, V, Ti) and unwanted tramp elements. These alloys enhance strength, hardness, wear resistance, ductility, corrosion resistance, and grain refinement, but variability in scrap makes property control challenging. Microalloying during billet production can boost rebar strength without affecting other characteristics if additions stay below 0.3%, though it is costly and less common in India. High-quality billets, skilled manpower, and rolling mills with automatic cooling beds are essential for precise TMT bar production and consistent mechanical performance.

Melting point and corrosion: the hidden link in steel

Steel melts over a temperature range, not at a single point like pure iron (1538 °C), due to alloying elements and impurities. Secondary steel typically softens around 1400–1450 °C and becomes fully liquid near 1500 °C, depending on scrap chemistry. Carbon significantly lowers the melting temperature, while higher alloy or tramp elements and pressure can further influence melting behaviour and corrosion response.

The melting point of steel depends on the strength of atomic bonding in its crystal lattice, which is controlled by chemical composition. Alloying elements and residual impurities modify phase stability and distort the Fe lattice, producing a melting range rather than a single temperature.

In secondary steelmaking, melting point, density, and specific gravity control how scrap melts, mixes, and refines in the furnace. Variations in scrap density affect heat transfer, melting efficiency, and slag–metal reactions, while heavy residual elements like Cu, Sn, and Sb are difficult to remove. Proper temperature and chemistry control are therefore essential to avoid segregation, ensure uniform melting, and

Table 1: Melting Temperatures of Key Metals
(Callister & Rethwisch, 2020; Davis, 1998)

Metal / Alloy	Melting Point (°C)	Density (g/cm^3)	Specific Gravity
Aluminium	660.3	2.70	2.70
Chromium	1,907	7.19	7.19
Cobalt	1,495	8.90	8.90
Copper	1,085	8.96	8.96
Gallium	29.8	5.91	5.91
Gold	1,064	19.32	19.32
Iron (α-Fe)	1,538	7.87	7.87
Steel (Carbon Steel / Rebar Grade)	~1,370–1,510	7.75–7.85	7.75–7.85
Lithium	180.5	0.534	0.534
Magnesium	650.0	1.74	1.74
Manganese	1,246	7.21	7.21
Molybdenum	2,623	10.28	10.28
Nickel	1,455	8.90	8.90
Platinum	1,768.3	21.45	21.45
Potassium	63.5	0.862	0.862
Silver	961.8	10.49	10.49
Titanium	1,668	4.51	4.51
Zinc	419.5	7.14	7.14

produce durable secondary steel comparable to primary steel.

Why these Properties Matter for Secondary Steel?

TMT rebar production relies heavily on raw material quality and rolling, especially when using re-rolled scrap, whose chemistry often falls short for strength and durability. Mild-steel rebars from general billets receive no special strengthening. However, with impurities removed and chemistry tightly controlled through refining, dephosphorisation, desulphurisation, carbon tuning, and controlled Mn/Si/microalloy additions, secondary steel achieves a clean, stable ferrite–pearlite microstructure with refined grains. Eliminating tramp elements prevents brittleness and ensures uniform solidification, corrosion resistance, and reliable mechanical properties. With disciplined scrap selection and BIS-compliant testing, recycled steel delivers strength, ductility, weldability, and durability equivalent to primary steel, making it fit for demanding infrastructure applications.

Primary vs Secondary Steel: What Sets Them Apart?

Primary steel maintains P and S below 0.03% and negligible residuals, ensuring high weldability, toughness, and corrosion resistance. TMT bars, introduced in India in the 1980s, are water-quenched hot-rolled bars that form a hard martensitic outer layer and a ductile ferrite–pearlite core, giving them high strength, ductility, and bendability. Structural steels are classified by carbon content—low, medium, high—with carbon controlling microstructure and mechanical properties.

- BIS/ISI Certification: Genuine primary steel carries official BIS/ISI markings, confirming quality standards.
- Brand Marking: It is mandatory to have an embossed brand, ISI Mark & Grade of Steel for every meter.

Table 2: Differences between Primary and Secondary Steel

Category	Primary Steel (BOF/EAF Route)	Secondary Steel (IF/EAF Scrap Route)	Impact on Corrosion Mechanisms
Raw Material Source	Iron ore → hot metal → refined steel	Scrap metal + Direct Reduced Iron (DRI) + returns	Mixed, contaminated scrap increases residual elements → micro-galvanic corrosion sites
Carbon (C)	Consistently controlled within 0.20–0.25%	Often fluctuates; 0.22–0.30% observed	Higher C increases pearlite content → reduced toughness → stress-assisted corrosion
Mangan -ese (Mn)	Controlled additions (0.8–1.5%)	Variability based on scrap	Imbalanced Mn alters steel hardenability → uneven corrosion fatigue performance
Sulfur (S)	≤0.040% (low due to desulphurization)	Often 0.040–0.060% in IF steel	High S forms MnS inclusions → pit initiation sites → severe localized corrosion
Phosphorus (P)	≤0.040%	Often 0.040–0.080%	High P causes grain-boundary embrittlement (In freezing conditions, the presence of phosphorus can exacerbate the embrittlement phenomenon, leading to reduced mechanical properties and increased brittleness. This can result in a decrease in impact strength and an increase in susceptibility to stress corrosion cracking at low temperatures→ intergranular corrosion sensitivity
Silicon (Si)	Controlled (0.15–0.35%)	Varies more widely	High Si may increase scale formation → uneven protective oxide layers
Chromium (Cr)	Very low unless alloyed	Higher due to scrap contamination	Mixed Cr levels create heterogeneous passive films → differential aeration corrosion
Copper (Cu)	0.10–0.20%	Can exceed 0.25–0.50%	High Cu accelerates pitting; Cu-rich areas create micro-galvanic cells
Tin (Sn)	Traces only	Higher due to scrap	Sn segregation increases brittleness → enhances corrosion under tension
Nickel (Ni)	Very low	Moderate in scrap	Non-uniform Ni segregation affects passivity → unstable oxide protection
Arsenic (As)	Typically, negligible	Often present in recycled scrap	Arsenic weakens grain boundaries → promotes intergranular corrosion
Nitrogen (N)	Low due to controlled steelmaking	Higher in IF process	High N leads to nitrides → crack initiation → corrosion at inclusions
Oxygen (O)	Well, controlled in BOF/EAF refining	Poor control in IF route	High O produces oxide inclusions → severe corrosion initiation points
CE (Carbon Equivalent)	0.40–0.50	0.50–0.60	Higher CE → reduced weldability, more micro-galvanic zones, faster corrosion initiation.

- Surface Quality: Primary steel features a consistent, smooth, and rust-free finish.
- Price Check: If the cost is significantly lower than the market rate, it is likely secondary steel.

Too little carbon weakens steel, while excess carbon, sulphur, and phosphorus increase brittleness and reduce weldability, making strict metallurgical control essential. Although electric arc furnaces produce cleaner steel, most Indian plants rely on induction furnaces, which have limited refining capability and may yield inconsistent billet quality.

Sulphur forms MnS inclusions that influence microstructure and corrosion behaviour; levels above about 0.05% increase brittleness and welding problems unless balanced with manganese. Phosphorus is also kept low because it segregates at grain boundaries, reducing ductility and impact strength and increasing embrittlement risks, especially in low temperatures.

Steel's thermal expansion closely matches that of concrete and it bonds well with it, making it ideal for reinforcement. In reinforced concrete, steel bars act as passive reinforcement, while prestressed concrete uses high-strength tendons as active reinforcement. Rebars therefore require high tensile strength with adequate ductility for bending and safe structural performance.

Fig 1: Bend and Rebend test for Reinforcing bars

Comparison of chemical composition of primary steel, secondary steel, and BIS/ASTM limits for reinforcing bars.

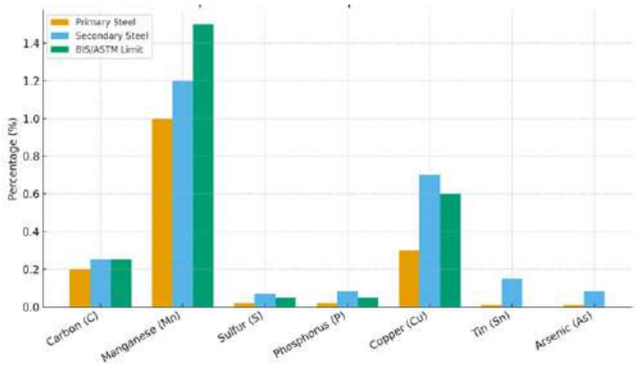


Fig 2: Comparison of Chemical Composition of PS and SS and BIS/ASTM Limits for Reinforcing bars (ASTM International,2023; Bureau of Indian Standards,2021; ASM International,2018; World Steel Association,2019)

- The comparative chart and dataset showing material compositions of Primary Steel, Secondary Steel, and BIS/ASTM limits demonstrate how secondary steels exceed safe impurity thresholds, especially for S, P, Cu, Sn, and As, which directly accelerate corrosion.
- This chart highlights the compositional differences between primary steel (blast furnace route), secondary steel (scrap-based EAF/IF route), and the permissible limits prescribed in BIS (IS 1786:2008) and ASTM (A615/A706) standards.
- Overall Trend: Primary steel compositions are within safe ranges, leading to uniform corrosion over time. In contrast, secondary steels with elevated impurities are more prone to localized pitting, faster chloride-induced deterioration, and reduced service life.
- BIS sets tight controls on S and P (≤0.04%). But in secondary steel rebars, values often cross 0.06 -0.08%, leading to durability issues.
- ASTM A706 (controlled composition) is preferred for welded applications and durability; ASTM A615 (more flexible) may allow higher impurities

Corrosion: The Hidden Threat

Steel is vital for infrastructure, but corrosion is its biggest threat. Moisture, chlorides, and carbonation trigger rust, cracking, and strength loss. In rebars, excessive hardness, poor ductility, and weak re-bendability further compromise safety.

In secondary steel, residuals like S, P, Sn, As, and Sb accelerate corrosion by forming inclusions and segregating at grain boundaries, weakening protective films. Excess carbon increases intergranular corrosion.

Weathering steels (ASTM A242/A588) resist atmospheric corrosion via Cu, Cr, and Ni micro-alloying, forming a dense, protective patina. High-strength quenched and tempered steels (ASTM A514/A852) achieve toughness and high strength through controlled martensitic microstructures.

In reinforced concrete, rebar corrosion starts when moisture and oxygen breach the protective alkaline film. While concrete durability is crucial, rebar chemistry is equally critical. Mild steel (MS) rebars are generally more corrosion-resistant than CTD or TMT bars, benefiting from protective films formed during cooling, unlike CTD (residual strain) or TMT (induced stress) bars that are more vulnerable.

Breaking Barriers to Unlock the Next Growth Wave

India's secondary steel sector can no longer be viewed through the lens of origin, it must be judged by precision. Consistent chemical composition is the real currency of quality. When scrap varies, chemistry drifts. When impurities rise, corrosion commands. When microstructures shift, reliability collapses.

Modern scrap-based steelmaking, with LRF, OES, continuous casting, and automated chemistry control, can match primary steel in every parameter. What holds it back is not capability, but inconsistency.

India stands at an inflection point:

- Control the chemistry, and secondary steel becomes a powerhouse, BIS-compliant, high-performance, and crucial to a circular, sustainable economy.
- Ignore the chemistry, and unpredictability, corrosion, and microstructural instability follow.

The way forward is unmistakable:

- Standardize scrap.
- Modernize refining.
- Mandate chemical certification.
- Retire the term "secondary steel" once and for all.

Steel recycled is not steel reduced—it is metal reborn. But its rebirth must be controlled. India's next growth wave will rise on steel with chemistry that inspires confidence. Because when we fine-tune the elements within the bars, we build not just stronger structures, but a stronger nation.

Part 1 outlined the broader issues, variability, and performance challenges associated with secondary steel. Based on the test results evaluated, Part 2 presents a detailed discussion in the way forward on the actual chemistry of secondary steel and established recommended limits for chemical composition to enhance its mechanical performance and consistency. Together, these sections provide a clear, evidence-based roadmap for improving the quality and reliability of secondary steel production.

References

1. ASM International. (2006). ASM handbook, volume 1: Properties and selection—Irons, steels, and high-performance alloys. ASM International.
2. ASM International. (2006). ASM handbook, volume 13A: Corrosion. ASM International.
3. ASM International. (2018). ASM handbook, volume 1: Properties and selection—Irons, steels, and high-performance alloys. ASM International.
4. ASTM International. (2022). ASTM A240/A240M: Standard specification for chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels and for general applications. ASTM International.
5. ASTM International. (2023). ASTM A615/A615M-23: Standard specification for deformed and plain carbon-steel bars for concrete reinforcement. ASTM International.
6. ASTM International. (2023). ASTM A706/A706M-23: Standard specification for low-alloy steel deformed bars for concrete reinforcement. ASTM International.
7. Bureau of Indian Standards. (2021). IS 1786: 2008 (Reaffirmed 2021), High strength deformed steel bars and wires for concrete reinforcement. BIS.
8. Bureau of Indian Standards. (1985). IS 1786: 1985, Indian standard specification for high strength deformed steel bars and wires for concrete reinforcement (3rd rev.). BIS.
9. Callister, W. D., & Rethwisch, D. G. (2020). Materials science and engineering: An introduction (10th ed.). Wiley.
10. Davis, J. R. (Ed.). (1998). Metals handbook desk edition (2nd ed.). ASM International.
11. Davis, J. R. (Ed.). (2000). Corrosion: Understanding the basics. ASM International.
12. Fontana, M. G. (2005). Corrosion engineering (3rd ed.). McGraw-Hill.
13. Fruehan, R. J. (Ed.). (1998). The making, shaping and treating of steel: Steelmaking and refining (11th ed.). AISE Steel Foundation.
14. Ghosh, A., & Chatterjee, A. (2014). Ironmaking and steelmaking: Theory and practice (2nd ed.). Springer.
15. Manu, K. C., Madhushree, C., Chandini, M. S., Shree, N., Hemanth, S., & Jeevan, T. P. (2025). Corrosion in steel structures: A review. Journal of Mines, Metals and Fuels, 73(1), 189–198. https://doi.org/10.18311/jmmf/2025/46985
16. Porter, D. A., Easterling, K. E., & Sherif, M. Y. (2009). Phase transformations in metals and alloys (3rd ed.). CRC Press.
17. Totten, G. E., & MacKenzie, D. S. (2003). Handbook of aluminum: Vol. 1. Physical metallurgy and processes. Marcel Dekker.
18. Totten, G. E., & MacKenzie, D. S. (Eds.). (2003). Handbook of aluminum and steel heat treatment. CRC Press.
19. World Steel Association. (2019). The impact of residual elements on recycled steel quality. World Steel Association.
20. Zhang, X. (2019). Tin in scrap steel: Behaviour, forms and removal challenges. Metals.

Deep Basements in Soft Clay Diaphragm Wall Casting Issues and Remedies

Mohith B Reddy
Manager - Projects

1. Introduction

Diaphragm walls (D-walls) are deep, cast-in-situ reinforced concrete retaining structures widely used for basements, metro stations, tunnels, and other underground works where controlling ground movement and groundwater ingress is essential. Constructed panel-by-panel using slurry-supported trenching, they commonly reach depths of 20–50 m, with thicknesses between 0.6–1.2 m. Their stiffness allows resistance against earth pressures, hydrostatic forces, and seismic loads, making them suitable for dense urban settings. Modern practices incorporate numerical modelling and soil–structure interaction principles to achieve more accurate predictions of wall behaviour during staged excavation (Mini et al., 2018; Iffland, 1978; Dong, 2024; Zeng et al., 2025).

2. Case Study:
Construction Challenges in Chennai

The project site in central Chennai is bordered by dense development, including a 13-storey hotel on the eastern side. A diaphragm wall system was chosen to ensure excavation stability for three basement levels while protecting these surrounding structures. The team encountered clay with strong elastic rebound, which caused the trench to deform after every excavation cycle. Rainfall further diluted bentonite slurry and weakened trench stability near the surface, resulting in outward bulging along several eastern boundary panels.

These distortions were only revealed after excavation reached the third basement level. Controlled chipping was used to correct misaligned surfaces, but in certain locations the process removed more concrete than intended, exposing reinforcement. Groundwater seepage also made uniform drying difficult before repair works. A coordinated remediation plan was then carried out to restore integrity

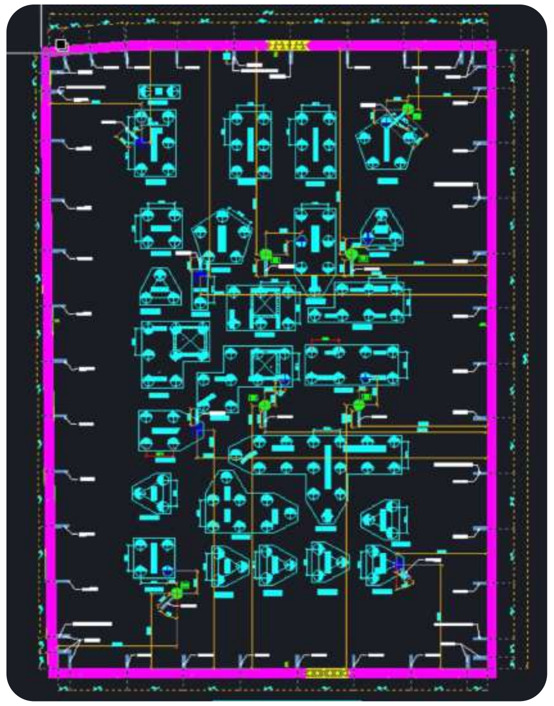


Fig 1: General Arrangement Drawing of the Site

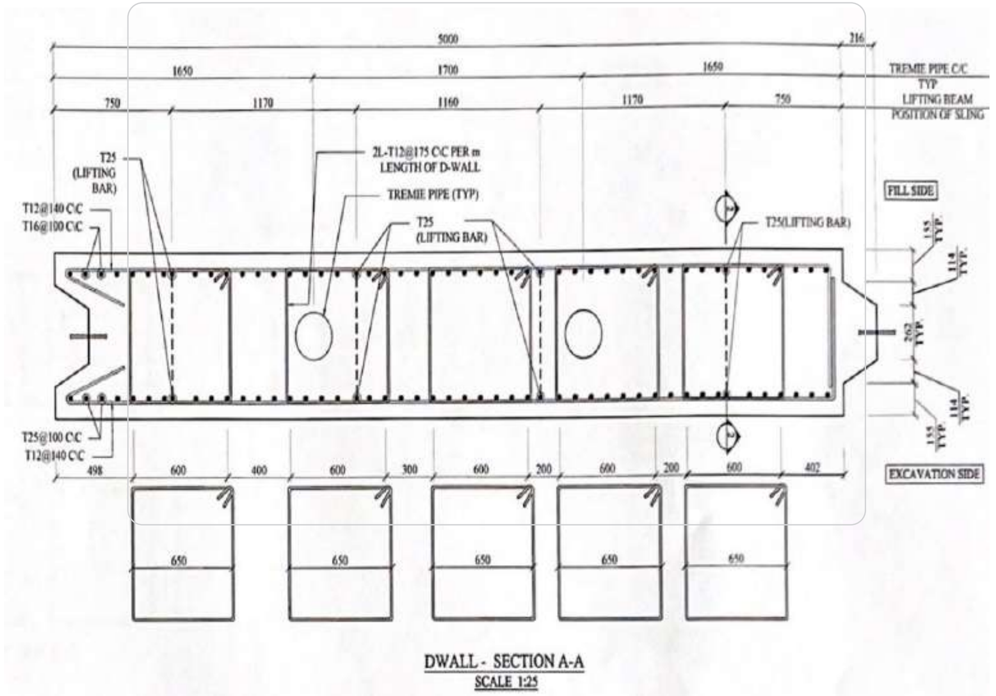


Fig 2: Excavation View of the Project Site

Fig 3: C/S details of the D-Wall

3. History and Development of Diaphragm Walls

Diaphragm walls were first developed in Europe in the 1940s–1950s when bentonite slurry trenching techniques were introduced in Italy for metro and basement projects (Mini et al., 2018). This innovation allowed deep, narrow trenches to remain stable during excavation and concreting, laying the groundwork for modern diaphragm wall construction. The 1960s–1970s saw worldwide adoption driven by hydraulic grabs, hydromills, and improved slurry circulation systems. Seminal work by Iffland (1978) established the theoretical framework for treating diaphragm walls as permanent structural elements, emphasising residual stresses and wall–soil interaction. Contemporary research focuses on installation effects, groundwater interactions, and three-dimensional trench stability. Dong (2024) demonstrated the significance of construction-stage behaviour on wall deflection. Zeng et al. (2025) highlighted deformation triggered solely by pre-excavation dewatering. Wu et al. (2026) expanded understanding of stability issues in irregular trench geometries. These contributions show the evolution of diaphragm wall technology into a sophisticated geostructural system.

D) CODES & STANDARDS FOR THE D WALL & PILE FOUNDATIONS

❖ **Diaphragm Wall (D-Wall):**

- **IS 9556:1980** – Code of practice for design and construction of diaphragm walls (India).
- **IS 4651 (Part 5):1980** – Code for planning and design of ports and harbors (diaphragm walls in marine works).
- **EN 1538 (Europe)** – Execution of special geotechnical works – diaphragm walls.
- **BS 8002 (UK)** – Earth retaining structures.
- **ACI 336.3R (USA)** – Guide for design & construction of diaphragm walls.

Fig 4: Codes and Standards for D-wall and pile foundations

4. Advantages of Diaphragm Walls

Diaphragm walls offer continuous, stiff, and watertight retaining systems ideal for deep excavations in dense urban areas. Their thickness and embedment depth allow them to resist high bending moments, shear forces, and hydrostatic pressures, making them suitable for deep basements, high groundwater conditions, and seismic environments. Because diaphragm walls are constructed using slurry trenching rather than driven methods, they generate minimal noise and vibration, making them ideal for construction near sensitive buildings. Modern design approaches, incorporating advanced numerical modelling and soil–structure interaction principles, allow engineers to optimise wall geometry and support systems for improved safety, durability, and cost efficiency (Dong, 2024). Additionally, diaphragm walls can function as permanent basement walls, reducing structural footprint and improving space utilisation in restricted urban sites (Iffland, 1978). These combined benefits make diaphragm walls one of the most robust and versatile retaining systems for deep excavations.

Fig 5: Reinforcement Cage Being Lowered into a D-Wall Panel

5. Disadvantages and Limitations of Diaphragm Walls

Despite their many advantages, diaphragm walls present significant construction and design challenges. They require specialised machinery, skilled operators, and strict control of slurry properties, reinforcement cage alignment, and trench verticality. Defects such as bulging, misalignment, inadequate cover, or leakage paths may remain hidden until excavation exposes the panels (Iffland, 1978). Although D-walls are stiff, they still induce ground movements—especially if construction-stage effects and groundwater interactions are not captured in the design (Dong, 2024). Their initial cost, mobilisation requirements, and quality-control demands are higher than those of simpler systems, and oversimplified modelling can result in inaccurate predictions of deformation and serviceability issues (Mini et al., 2018).

6. Discussion: Remedial Measures Implemented

The remedial plan focused on restoring structural integrity, surface alignment, and watertightness along the affected diaphragm wall panels. Controlled chipping was used to remove bulged concrete and reshape the internal face of the wall, exposing and cleaning the underlying reinforcement where cover had been lost. Corrosion inhibitors were immediately applied on the cleaned steel to protect against longterm deterioration, followed by active dewatering along the excavation face to ensure a suitably dry and stable substrate for subsequent repair layers. A full shotcrete layer was then applied to reinstate the required cover, close local irregularities, and create a continuous internal profile that would act as both a structural and protective facing.

For this repair, the shotcrete mix is recommended to be either a high performance microconcrete or a structural concrete with a characteristic strength grade not less than, and preferably higher than, the original diaphragm wall concrete grade of M45, in order to provide superior durability and stiffness in the repaired zones. Using a higher grade mix helps to compensate for any local loss of section, improves bond to the prepared surface, and enhances resistance to ground water induced deterioration over the service life of the basement structure.

CONCRETE MIX DESIGN DETAILS FOR THE D WALL- M45 GRADE							
S.No	Raw Material	DesignQty (Kg)	%Mois%Abs / Corr (Kg)	Concreted (Kg)	Required (Kg)	Batched (Kg)	% Variation
1	CA12mm	442.00	0.00	442.00	2210.00	2182.00	-1.27
2	CA20mm	665.00	0.00	665.00	3325.00	3348.00	0.69
3	FAWCS	774.00	3.60	802.80	4014.00	4017.00	0.07
4	C1	440.00	0.00	440.00	2200.00	2196.00	-0.18
5	WATER	155.00	-28.80	126.20	631.00	629.00	-0.32
6	ADMH PLAST	2.20	-0.20	2.00	10.00	10.00	0.00
	TOTAL	2478.20	0.00	2478.00	12390.00	12382.00	-0.04

Fig 6: Concrete Mix design details for the D-wall

Fig 7: Corrosion Treatment Applied on Exposed Reinforcement

Fig 8: Application of shotcrete layer over prepared diaphragm wall surface using compressed air spraying equipment.

Recommended Practices

Precasting dewatering around the D-wall In sites where high groundwater levels are a primary risk factor, it is advisable to implement radial or linear dewatering around the diaphragm wall alignment, extending roughly 1 m on either side of the wall. This precasting dewatering reduces hydrostatic pressure on the trench, improves slurry stability, and limits dilution during excavation and concreting, thereby minimising the likelihood of bulging and seepage-related defects.

Use of polymer enhanced bentonite slurry For soft clay sites with high water tables, polymermodified bentonite slurry is strongly recommended over conventional bentonite. Polymer bentonite systems typically provide better filtercake quality, higher tolerance to ground water contamination, improved suspension of fines, and more stable rheological properties over time, which together enhance trench stability and reduce the risk of wall deformation and concrete–slurry contamination during casting.

Bentonite (as per IS 9556)/Polymer Mud (AS per API 13B code)

Bentonite/Polymer should be tested as per standard operating procedure. The diaphragm wall excavation / grabbing will be done by Bentonite/polymer mud circulation to prevent collapsing /caving in soil inside panel. Bentonite/polymer shall be stored /prepared in a designated area as mentioned above.

To assure that Bentonite/Polymer slurry /mud is in according with standard operating procedure using mixing tank motor pump for Bentonite/polymer mixing mud circulation. The quality of Bentonite/polymer slurry /mud used for the excavation /grabbing will be verified during preparation and excavation, prior to concreting (before steel cage lowering).

Checking parameter (REFER IS 9556 1980, PAGE NO 8 TABLE 6.1)

- **Marsh viscosity**
- **pH test**
- **Density by hydrometer.**

IS CODAL PRACTICE FOR BENTONITE SLURRY TESTING IS 9556.

6. SPECIFICATIONS OF BENTONITE SLURRY

6.1 Following tests are normally carried out on freshly prepared bentonite slurry to be used in diaphragm walling:

Type of Test	*Method of Test*	*Permissible Value at 20°C*
Density	Mud balance or hydrometer	1·04 to 1·10 g/ml
*p*H value	*p*H indicator paper strips	9·5 to 12
Viscosity	Marsh cone method	30 to 90 seconds
10-minute gel strength	Shearometer or vane shear apparatus	1·4 to 10 N/m^2 (14 to 100 dyn/cm^2)

Fig 10: Polymer Bentonite specs according to IS code.

API 13 B CODAL PROVISION FOR POLYMER SLURRY

On the following table we recommend the slurry quality parameters applicable.

Parameters	Fresh mix	Reused slurry	Prior to concrete pour
Viscosity Cone Marsh API (s)	55-140	55-140	50-140
Density (kg/m3)	1.000-1.004	≤1.003	≤1.0025
Sand Content (%)	-	≤1%	≤1%
pH	11 – 12	11-12	7 – 12

Fig 11: Codal provision for polymer slurry

Control of concrete slump during tremie placement Tremie concrete used for diaphragm wall panels should have a controlled slump, generally in the range of 180–200 mm, to ensure adequate flow, selfcompaction, and proper displacement of slurry without segregation. Slumps significantly below this range may lead to poor filling and honeycombing, while excessive slump can increase segregation risks and reduce uniformity, especially in deep panels.

7. Conclusion

This case study demonstrates the complex challenges of constructing diaphragm walls in soft clay environments and underscores the importance of careful slurry control, trench stability monitoring, and construction-stage assessment. While diaphragm walls deliver excellent stiffness and groundwater resistance, their performance depends heavily on execution quality.

The systematic remedial measures—including chipping, reinforcement protection, dewatering, shotcreting, and grouting—proved effective in restoring the wall's performance. These lessons highlight the need for proactive site supervision and responsive engineering intervention during deep excavation works.

References

DesignTree Service Consultants. (2024). Deep basements in soft clay: Diaphragm wall casting issues and remedies. Chennai.

Dong, Y. P. (2024). Effect of diaphragm wall construction process on the performance of braced excavation. Technical University of Denmark.

Iffland, J. S. B. (1978). Practical design of concrete diaphragm walls. ACI Proceedings.

Mini, M. P., Kurian, B., & James, A. (2018). A theoretical study on the analysis of diaphragm wall. IRJET, 5(5), 4089–4094.

Wu, Y., Hao, R., Peng, Y., Tan, Y., Li, H., & Gao, C. (2026). Trench wall instability. Results in Engineering, 29, 108468.

Zeng, C., Powrie, W., Xu, C., & Xue, X. (2025). Wall movement during dewatering. Underground Space, 22, 355–368.

Food Waste Treatment & Recycling, Management and Production of Value-Products-An update on Methodologies and Current Trends

B.O. Prasanna Kumar
Jt. Managing Director

Introduction

India is the second-largest food producer in the world, accounting for around 10.1% of global food output. Forty percent of India's total food production is considered food waste (FSSAI, 2025). Every year, one person wastes about 50 kg of food. Food is defined as any material that is primarily meant for human (or other animal) ingestion, whether it is raw, semi-processed, or processed. Frequently, "food" is accompanied with its opposite, "inedible parts," which are unfit for human consumption. "Food waste" refers to the removal, disposal, or discarding of any sustainable food or inedible portions of food from the food supply chain prior to and after consumption.

Composition, global statistics, and policies

A variety of sources, such as homes, the hospitality industry, and food processing facilities, release both leftover and precooked food. Food waste can be either liquid or solid, from semi-solid to solid. Generally high in starch, cellulose, lignin, and monosaccharides, food waste primarily consists of the food items themselves, portions of the food items, or other parts or objects related to specific food items. Therefore, food waste may be categorized as "avoidable," "potentially avoidable," or "unavoidable" to examine and classify the extent to which food waste could or could not be controlled.

S/N	Food waste Classification	pH	Total solid (%wb)	Volatile Solid (%wb)	Total organic Com-pound (%)	Total Nitrogen (%)	Fat (%)	Protein (%)	Carbohy-drate (%)	Phos-phorus (%db)	Potas-sium (% db)
1	Dairy product	6.29	35.54	36.65	29.72	1.58	28.43	14.05	57.51	1.33	0.87
2	Fats, oil,and grease	3.55	60.75	59.29	65.64	0.64	91.19	1.23	7.59	0.12	0.08
3	Ice cream	4.84	11.38	10.91	26.5	0.37	39.6	8.9	53.1	0.28	0.53
4	Fruit and vegetable	5.69	13.87	12.71	19.57	0.62	1.36	5.2	39.01	0.67	3.28
5	Confectionery (canned goods)	5.72	22.93	18.43	17.38	1.24	2.79	24.38	72.83	0.91	2.61
6	Cereals and cereal products	5.84	90.33	72.21	14.79	2.07	3.83	11.19	84.98	0.64	0.35
7	Bakery wares	5.5	88.81	71.51	43.14	2.37	6.03	12.92	81.05	0.44	0.15
8	Meat and Meet products	6.2	46.99	41.6	25.18	4.32	57.74	25.17	17.1	0.76	0.63
9	Fish and Fish products	6.49	46.12	39.25	17.72	4.38	65.53	27.48	6.98	1.48	1.46
10	Eggs and Egg products	7.43	49.64	22.77	16.26	3.04	73.06	19	7.94	0.88	1.13
11	Sweeteners and sweet goods	5.49	70.51	63.94	32.98	1.01	16.21	5.85	77.89	0.23	0.43
12	Sauces, spices, and soups	6.09	46.44	34.58	23.85	1.82	1.35	11.32	87.33	0.42	2.03
13	Beverages	4.25	36.36	33.69	4.75	2.13	0.07	14.98	84.95	0.23	1.66
14	Ready to eat food or restaurant waste	5.88	64.84	44.18	39.5	2.31	13.05	15.59	65.36	0.56	1.96
15	Other expired food	6.38	58.85	47.13	42.36	2.13	16.96	18.58	64.46	0.19	0.57

Table1: Food waste categories and their chemical characterization.

According to studies, 1.3 billion tons of food—including fresh fruits, vegetables, meat, baked goods, and dairy products—are wasted within the food supply chain. Different types of food waste have different compositions depending on their ingredients. The primary components of food waste include lipids, proteins, carbohydrates, and trace amounts of inorganic substances. Table 1 lists the many types of food waste along with a chemical description of each. According to studies, food waste that contains rice and vegetables is high in carbohydrates, but food trash that contains meat and eggs is high in proteins and fats. The primary causes of food waste are store operations, services, and customer behavior.

According to data collected by the Food and Agriculture Organization (FAO) in 2025, the percentage of food loss or waste generated was close to 35% of the total amount of food produced worldwide (FAO). Gross food waste makes up around one-third of global food output, according to the FAO. Nearly 14% to 21% of food losses in developing and underdeveloped countries have been observed and reported to occur during processing stages (a significant portion of post-harvest sorting and grading losses, such as fruit and vegetable waste), whereas under 2% have been reported for the same in developed and industrialized nations.

According to studies, developed nations produce 225 million tonnes of food waste at the consumer level from a variety of sources worldwide. This amount is almost equal to the total amount of food produced, when compared to other significant values. Fruit and vegetable processing waste was identified as the fifth highest contributor to total food waste (equating to 8% of total food waste) in nations such as Europe. According to a Southern Asia UNEP research, food waste (kg/capita) is estimated to be 50 kg/capita in India, 79 kg/capita in Bhutan, 65 kg/capita in Bangladesh, and 82 kg/capita in Afghanistan annually (UNEP).

According to studies, the food waste in Uttarakhand and Andhra Pradesh is 73 and 20 kg/capita, respectively, whereas Rajam, Andhra Pradesh, has an estimated 58 kg/capita. An estimated 68,760,163 tonnes of food waste are produced annually in Indian households. India's FW composition is almost the same as China's, with water making up 57, protein 7.4, fat making up 3.7, and carbs making up 32. However, FW from Brazil and the USA has been observed to have relatively higher protein content. Food waste from fruit and vegetable markets, homes, and juice bars had an 85% moisture content, according to Indian domestic food waste characteristics. Approximately 89% of total solid and a ratio of C/N of 36.4, which was comparable to other South Asian countries.

Segregation at the source was the main focus of the solid waste management (SWM) rule that was announced by the Union Ministry of Environment, Forests, and Climate Change (MOEF & CC) in India in 2016. The goal of this rule was to turn waste into wealth through recovery, reuse, and recycling (RS bill, Gvnmt of India 2016). All residences, hotels, restaurants, resorts, colleges, and businesses must separate biodegradable garbage and establish a collection mechanism to guarantee that food waste is used on-site for composting or bio-methanation. The Central Government was required to announce the creation of a food waste reduction committee in the Official Gazette by the mandatory food waste reduction bill that was introduced in 2018. Indian government proposed a new biofuel policy with an indicative aim of 5% biodiesel blending in diesel and 20% ethanol blending in petrol by 2030. The Department of Biotechnology (DBT) government of India has financed eight waste-to-energy projects that were begun to develop/ demonstrate unique and feasible technology for the sustainable usage of MSW for cleaner and pollution-free environments and electricity generation (DBT-India).

Contributors to food waste

Cereals, fruits, meat, fish, beverages, and other food waste are all categorized in the most straightforward way possible. Based on factors like mass (more frequently), energy content, economic cost, etc., this classification helps to estimate the quantity of food wasted. There are many instances of food waste classifications based on the food industry. According to the recently released Food Loss and Waste Accounting and Reporting Standard, the Codex Alimentarius General Standard for Food Additives (GSFA) system or the United Nations Central Product Classification (CPC) system should be used as the primary codes for this kind of classification. In situations requiring more accurate categorization, the Global Product Category (GPC) code or the United Nations Standard Products and Services Code (UNSPSC) are used as additional codes.

Food waste is a major problem in many areas of the food economy, such as dairy, fruits and vegetables, seafood, and meat. 42% of food waste is produced in households, 39% in retail establishments, and 14% in food service establishments, according to EU estimates. Waste mostly arises during product manufacturing and processing in the dairy industry. 20–40% of the total product is thrown away because it is not the ideal size, shape, or color, making fruits and vegetables the product with the highest percentage of waste attributable to product standards. Requirements from retailers and customers may cause edible food to be rejected and squandered. For example, the Australian banana sector rejects up to 40% of its total production because of low retail prices and stringent regulations making it unsuitable for farmers to sell. According to studies, peeling or skinning fruits and vegetables might result in 25–30% of the product weight being wasted. Significant weight losses are also a result of canning, drying, and freezing, and the waste that results from these processing techniques can also raise. Because of the increased supply, food by-products may also result in a decrease in the market price of products. This may result in more primary product waste. Food processing may result in a greater quantity of waste from so-called "recovered resources". There is also a significant amount of production waste in the seafood industry. An analysis of shrimp trawlers in Northern Peru that were in operation from April 2019 to March 2020 showed of the 17.8% of the overall catch, 82.2% represented bycatch, and 50.6% represent discards. In the meat sector, it is estimated that up to 23% of meat production is lost and wasted throughout the entire food chain. This loss and waste occur at various stages of the meat supply chain, with the largest portion occurring at the consumption level, accounting for 64% of the total food waste. This is followed by manufacturing (20%), distribution (12%), and primary production and post-harvest stages (3.5%).

Major generators of food wastage in India are hotels, hostels, restaurants, cafes, supermarkets, residential blocks, airline cafeterias, and also food processing industries. At present, majorly, food waste in India is sent for composting for fertilizer production; however, some of these are buried inside the land, which causes land pollution and leads to harming natural resources.

Distribution and aggregation are two crucial components of the food supply chain. Large amounts of milk are wasted as a result of spoiling, overproduction, and breakage in nations like India where milk is delivered in an unstructured manner from rural to urban areas over great distances. Since milk must be packed in order to be considered an aggregated product, it is frequently still in loose form. A large amount of this waste happens at markets and at the consumer level. A projected 931 million tons of food, or 17% of all food available to consumers in 2019, ended up in the trash cans of homes, businesses, eateries, and other food services, according to the UNEP.

Food waste characteristics

Wet food waste often consists of kitchen garbage, such as cooked and uncooked food waste, eggshells, and bones; flower and fruit waste, such as juice peels and houseplant waste; green waste from vegetable and fruit vendors and stores; waste from food and tea stalls and stores; and so on. This fruit waste has a significant negative impact on ecosystems because of its moisture content and microbial makeup. Among the many elements that have recently contributed to the impact on the environment, fruit waste has been identified as a serious concern. For instance, the percentage of wasted materials in most fruit processing businesses is frequently very high (e.g., mango 30–50%, banana 20%, and pomegranate 40–50%), depending on the harvesting area and method.

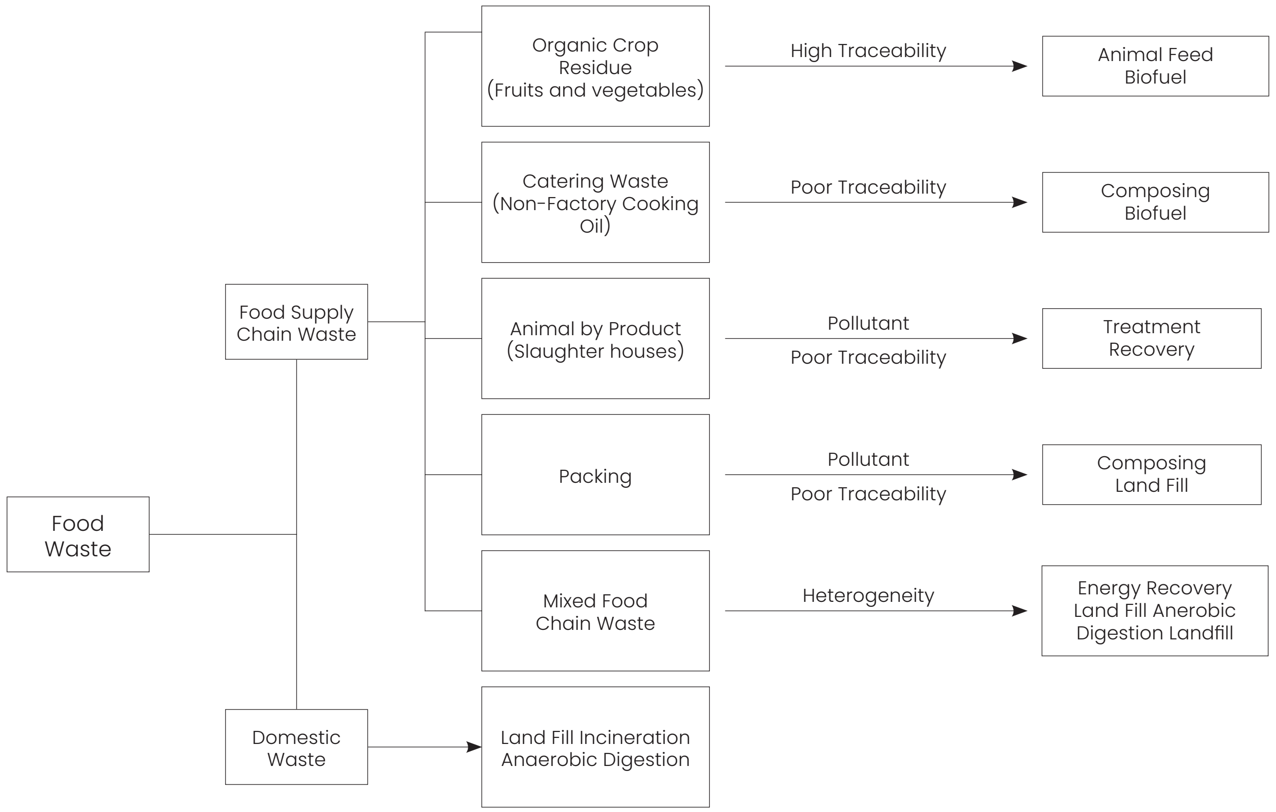


Fig 1: Schematic representation of food waste recycling chain and its applications

Nearly 46% of the fruits (including the waste from oranges and pineapples), vegetables, roots, and tubers that are grown are squandered, whereas 35% of fish and shellfish and 30% of grains are wasted, during 2019 study. According to study, about 60% of all food waste can be prevented (such as bread crusts, leftovers, spoiled fruits and vegetables, expired food items, etc.), 20% may be prevented (such as bread crusts, vegetable skins, etc.), and the remaining 20% cannot be prevented (such as animal bones, eggshells, banana skins, etc.). According to the ISO criteria, the main methods now used to treat food waste are landfilling, anaerobic digestion, composting, incineration, and sewerage.

When compared to the value of processed fruit, food processing waste (FPW) is thought to be negligible. Figure 1 is a pictorial representation of food waste management flow chart. Scientific interest in research on food waste management has increased over the past few decades, especially with regard to the production of valuable goods from vegetable waste. One attempt to make the treatment process more ecologically friendly is the production of numerous value-added products from food waste. In addition to reducing the environmental impact of food waste, this also minimizes the amount of losses and encourages "reuse" and "recycling" of the same.

Table 2: Advantages and disadvantages of different food waste treatment methods

Treatment process	Advantages	Disadvantages
Landfill	Low cost, simple technology, more used in developing countries	Pollution of groundwater, occupying a large amount of land and no resource recovery
Incineration	High degree of reduction, suitable for handling hazardous or toxic garbage	High cost, long capital recovery cycle, and low economic efficiency
Anaerobic digestion	High degree of automation, diversified products, high economic value	Need to screen suitable microorganisms, complex technology, discontinuous cycle, and difficult-to-treat biogas residue
Compost	High technology maturity, low cost	Low product value, environmental pollution, long cycle
Hydrothermal treatment	The product has high energy utilization value, simple process, low cost and short cycle	Hydrothermal treatment products need to be further optimized

Methods of food-waste recycling

The primary determinant of the food waste's degradability as a substrate is its chemical makeup. The complex substrate's diverse structure and region-specific constituents make it difficult to determine the precise percentage of each component. As the simplest and least expensive waste treatment method, food waste is primarily disposed of by being dumped in landfills. This approach, however, opens the door for extremely alarming air and land contamination (and occasionally even water pollution). Because they are less expensive than anaerobic digestion, composting and incineration are additional waste treatment techniques that are used more frequently.

Large volumes of greenhouse gases and other dangerous chemicals are produced by these processes, and when they are discharged into the environment, they can create a variety of imbalances and malfunctions. Food waste dumping is responsible for about 7% of global greenhouse gas emissions. According to study during 2018 approximately 70.5% of the waste produced by the food processing industry and 50% of the waste gathered from the wholesale and retail industries are burned; 21% of the waste from the foodservice industry is burned, whereas 54% is disposed of in landfills; and 33.4 percent of the total amount of food waste accumulated from households is burned. 27.5 percent of it is dumped in landfills. Table 2 describes the advantages and disadvantages of different food waste treatment methods.

Anaerobic digestion

A number of researchers have looked into the possibility of using food waste as a biomethanation substrate. It is the most widely utilized therapeutic approach worldwide. A two-stage anaerobic digestion of fruit and vegetable wastes was proven during 2025, obtained a methane production of 530 mL/gVS and a 95.1% volatile solids (VS) conversion. Using about 54 different food types, during 2023 study found that the methane yield varied depending on the waste's origin, ranging from 180 to 732 mL/g VS. Enzymatic hydrolysis, acid generation, and gas production are the three main stages of anaerobic digestion. In the first stage, hydrolases released by facultative or obligatory anaerobic bacteria break down big polymer molecules that microbes cannot carry to cell membranes. The second stage, known as acidogenesis, involves the fermentation of hydrolytic products to produce volatile fatty acids, including butyrate, valerate, acetate, propionate, and isobutyrate, as well as carbon dioxide, hydrogen, and ammonia. Facultative anaerobic bacteria use carbon and oxygen during acidification, establishing an anaerobic environment for methanogenesis. The acid phase products are converted into acetates and hydrogen by acetogenic bacteria that are members of the genera Syntrophomonas and Syntrophobacter. By employing hydrogen as an electron source to reduce carbon dioxide, a small number of acetate molecules are also produced. Methanogens, which are members of the Archaea, are responsible for methanogenesis, which occurs in the final stage. Carbon dioxide can be reduced or acetic acid can be fermented to make methane.

The degree of polymerization, crystallinity, lignin and pectin content, accessible surface area, and other characteristics of food waste impose recalcitrance. As a result, the anaerobic digestion of food waste that contains raw starch with a high degree of crystallinity—which prevents its hydrolytic degradation—is limited in its hydrolysis step. Before anaerobic digestion, pretreatment technologies such as mechanical, thermal, chemical, and biological ones can be used to decrease crystallinity and improve methane production from food waste. Previous studies have examined the impact of various pretreatment techniques on the anaerobic digestion of food waste.

As per study using food waste and treating it with a bead mill increased the amount of biogas produced by 28%. Compared to pig, cow, and whey manure, food waste as a substrate has the potential to provide a high biogas production. The anaerobic process of producing methane is a suitable way to handle food waste. The method uses food waste as a renewable energy source and is less expensive and produces less residual waste (Ng et al., 2020). Seeding, temperature, pH, the carbon-nitrogen (C/N) ratio, volatile fatty acids (VFAs), organic loading rate (OLR), alkalinity, total volatile solids (VS), hydraulic retention time (HRT), and nutrient concentration are all factors that affect the biomethanation process. Subsequently, the amounts of water-soluble substances including sugar, protein, amino acids, and minerals also affect the results. The stability of the digestive process may be accelerated by seeding. The microbial activity and efficiency of anaerobic digestion are influenced by the pH of a bioreactor. Microorganisms use nitrogen to construct their cell walls and carbon to meet their energy needs. According to study during 2019, methanogens do best at temperatures of about 35°C (mesophilic) and 55°C (thermophilic). Additionally, bacteria need a tiny amount of micronutrients for heavy metal ions for biomethanation and for the manufacture of enzymes as well as for sustaining enzyme function.

Composting

According to study during 2024, composting is a technique for managing environmental waste that entails the biological breakdown of organic materials. By stacking rows of biodegradable materials, aerobic windrow composting is a method for producing compost. Microbial communities are essential to the composting

process of organic waste. Given that it varies depending on its origins and the consumer's eating habits, composting food waste may be difficult. Different kinds of organisms that can interact with one another in their shared environment may form a microbial community. Compost is the result of microorganisms breaking down organic waste into its most basic components. Within four to six weeks, a humus-like structure will form. Windrows, aerated static heaps, and in-vessel systems are examples of composting techniques. In order to handle the large amount of trash, composting facilities typically use large-scale composting techniques (>100 kg/day). Appropriate composting parameters, including moisture content, carbon-to-nitrogen ratio, particle size, and aeration, must be satisfied in order to guarantee composting efficiency. Results are consistent and the process is controllable. To keep the combination moist, bulking agents such as sawdust, yard debris, and animal manures are added. This gives the mixture structure and porosity, which is necessary for adequate aeration and to maintain microbial activity. In this part, we summarize the key findings in this context using university composting data. Composting significantly lowers dorm trash while requiring little funding and oversight at Islamic International University Malaysia Kuantan campus. Soiled napkins and food scraps from establishments with on-campus foodservice operations are used for composting at Penn State University, an in-state university. According to a comparison of other universities, food waste production at Anna University was 350 kg per day, while at Kean University (KU) it was 125 kg per day, and at one of the University Malaysia Sabah cafeterias, it was 25.5 kg per day. Bulking agents and landscape applications are examples of composting techniques. Waste and paper

waste were successfully turned into compost in a cylindrical in-vessel composter for 105 days.

Thermal treatment

Thermal oxidation, which includes incineration, is the process of producing heat from waste materials. Heat is transferred to the steam engine boiler during this operation, and trash that contains hydrocarbons is burned during incineration to produce carbon dioxide, water, and other contaminants. Understanding a material's basic components is crucial to determining its composition of carbon, hydrogen, oxygen, nitrogen, sulfur, and ash before creating an efficient combustion process. According to study, thermal waste processing can swiftly decrease vast amounts of waste and transform it into electrical energy that the community may use.

One highly effective thermochemical conversion method for turning biomass into useful biofuels or value-added goods is hydrothermal treatment. Hydrothermal technique is used in a number of food waste treatment facilities worldwide. Unsorted, highly organic waste is fed into the reactor and subjected to steam for 30 minutes at a temperature of 220 °C and a pressure of 2.5 MPa. One byproduct of this process is hydrochar, which is a material that resembles powder. According to data on the boiler's gas emissions, air pollution is minimal. The applicability of this technology on an industrial scale is promising. The most significant influencing variables are the financial costs associated with material collection and transportation.

The hydrothermal process is separated into three categories based on the range of temperatures and pressures: hydrothermal carbonization, hydrothermal liquefaction, and hydrothermal gasification. Biomass is mostly converted into carbon materials via hydrothermal carbonization at temperatures between 180 and 260 C and pressures between 1 and 8 MPa. Fuel particles are created by hydrothermally carbonizing food waste; these solid particles can be used as domestic fuel since they have strong combustion qualities. According to the study during conducted during 2025, hydrothermal liquefaction typically takes place around 260–374^{0}C under 10–22. 1MPa. High-energy bio-oil (a blend of alcohol, sugar, furan, and other compounds) is the primary product. Furthermore, food waste contains a lot of organic material that can be hydrothermally liquefied to produce valuable products. For example, the extraction rate of pectin was as high as 11.63% by microwave-assisted hydrothermal treatment, and pectin could be used as a thickener and had important commercial value. The temperature, time and catalyst affect the reaction process based on the raw material composition.

Fermentation

A crucial part of many waste treatment programs is fermentation, which is the biological degradation of organic materials by microbes. Fermentation's contribution to the circular food economy is a crucial advantage of integrating it into food waste recycling. Fermentation lessens the environmental impact of traditional disposal methods by turning food waste into useful products including compost, biofertilizers, and biogas. Because the procedure doesn't require outside inputs, it encourages self-sufficient and sustainable waste management systems. This improves productivity and resource efficiency while also lessening the financial burden of trash disposal.

During fermentation, microbial populations interact dynamically to efficiently break down organic materials and produce advantageous byproducts. Certain bacteria thrive in low-temperature fermentation environments, adjusting to the conditions and affecting the overall makeup of microorganisms. On the other hand, anaerobic bacteria cannot survive under conditions created by aerobic fermentation and high temperatures. The fermentation process's bioseparation and extraction procedures improve the overall effectiveness of recycling food waste. By making it easier to extract valuable molecules from the fermented material, these procedures increase the recycling system's overall economic viability and allow for the extraction of bioactive substances.

Liquefaction

The ability of liquefaction to convert organic waste into useful resources while reducing its negative effects on the environment has attracted attention recently. The process of liquefaction involves heating food waste to high temperatures, usually between 150 and 400°C, while a solvent or water is present. This process leads to the breakdown of complex organic compounds into simpler molecules. A significant environmental advantage of this method lies in the eradication of pathogenic bacteria, present in food waste. Thus, enhancing the safety of the process reduces the risk of contamination and the spread of diseases. Liquefaction has been explored to produce biocrude oil, involving the conversion of organic matter into a liquid fuel which could be utilized as an energy source. Feasibility of employing food waste as a feedstock for biocrude oil production through liquefaction processes is reported. High-temperature conditions enable production of valuable byproducts such as soil amendment to enhance fertility and sequester carbon. Liquefication is a multifaceted approach that enables the simultaneous production of bioenergy and valuable byproducts, creating a more sustainable and resource-efficient food waste recycling system.

Food waste upcycling

The upcycling of food waste has proven to have the potential to contribute to the responsible production and consumption agenda of optimizing food resources through the conversion of food waste to either alternative food products or novel food products by utilizing various upcycling technologies. Broadly food waste upcycling are categorized into: integrated bio refinery technologies, microbial electrochemical technologies, Pyrolytic technologies, green extraction technologies, and conventional bio-waste valorization technologies.

Integrated Bio refinery Technology

To increase the amount of value-added goods extracted from food waste, this strategy integrates various waste treatments and conversion procedures. This comprises pre-treatment methods such enzymatic hydrolysis, acid, and milling to break down food waste biomass for upstream processing. With the use of suitable technologies, this is subsequently fed into the integrated bio-refinery system to extract the most value possible from the waste streams. In integrated biorefinery systems, technologies and processes such fractionation, fermentation, anaerobic digestion, cogeneration, biochemical and thermochemical conversion, separation, and purification have been employed. These technologies have been utilized to create bioelectricity and bioenergy as well as co-products such charcoal, bio-ethanol, bio-hydrogen, and biodiesel.

Microbial Electrochemical Technologies.

This process transforms chemical energy in food waste biomass into electrical energy by using biocatalysts, which include microorganisms like electro-trophic bacteria, fermentative bacteria, and electro-active bacteria like Geobacter sp. To create value-added goods, this technique can be applied as a stand-alone procedure or integrated into several systems as a component of a hybrid process. The technologies employ microorganisms to catalyze the electrochemical conversion of food waste into value-added products, including organic acids, lipids for the generation of biodiesel, biogas, biohydrogen, and bioelectricity. The method turns food waste into new goods, either with or without catalytic agents. Food waste is transformed into three primary products via thermochemical processes: biochar, bio-oil, and combustible gas. It entails heating biomass made from food waste to a temperature higher than 400°C with either partial or no oxygen present. Fast and slow pyrolysis, which is categorized, based on their process conditions and parameters are the most widely utilized pyrolysis techniques. Pre-treating food wastes before the pyrolysis process will provide higher-quality products.

Green Extraction Technologies.

It is a new extraction technique that uses green solvents instead of traditional solvents to extract natural bioactive compounds and/or value-added products from food waste. The approach has been utilized to extract natural bioactive components and compounds from agro-food waste, including pigments, enzymes, and antioxidants (flavonoids, polyphenols), etc. Because of its lower power requirements, less or nonexistent use of organic solvents, and ecologically friendly nature, it is seen to be a superior option than traditional extraction technologies. They

are predicated on the utilization of sustainable and renewable bioresources, green solvents like water, ethanol, supercritical CO_2, lower energy consumption, the production of co-products from the waste, compact unit operations, and the generation of non-denatured and eco-friendly extracts. The most commonly used green extraction technologies include microwave-assisted extraction (MAE), ultrasound-assisted extraction (UAE), hydrodynamic cavitation-assisted extraction (HCAE), and others. Table-6 is a comparison of various methods for food waste upcycling and their value-added products

Valorization of food waste to produce value-added products.

Single-cell protein Single Cell Protein (SCP).

One abundant source of organic matter that can be transformed into goods with added value is food waste. One promising strategy for waste management and sustainable production is the conversion of food waste into single-cell protein biofuel, bioplastics, and other value-added goods (SCP) is thought to be revolutionary for sustainable food production and is a promising

nutritional source with impact, especially when made from waste materials. Numerous microbes, including bacteria, fungus, and yeast, are the source of SCP. Utilizing microbes, the process transforms various substrates into microbial cell mass. Applications for the resultant microbial protein, or SCP, include animal feed, human meals, nutritional supplements, and more.

Bioethanol and Biodiesel:

Using a variety of appropriate methods, food waste can be used extensively as a raw material for the generation of biofuel. Using food waste to produce biofuel offers a viable sustainable alternative in light of the growing need for sustainable energy sources. According to study, biofuels made from food waste can lessen greenhouse gas emissions, lessen dependency on fossil fuels, and advance the ideas of the circular economy.

Three primary phases are involved in turning food waste into bioethanol: fermentation, enzymatic hydrolysis, and pretreatment. To optimize sugar recovery from food waste, mechanical, chemical, and biological techniques are used in the pretreatment process. Enzymatic hydrolysis follows, in which a combination of appropriate enzymes (mostly cellulase, β-glucosidase, and pectinase) is used to break down the polysaccharides into fermentable sugars. The final step is microbial fermentation to convert sugars into bioethanol. However, the technology poses few challenges, such as the handling of biomass and the application of pretreatment methods to improve the conversion of lignocellulosic materials into fermentable sugars. The production of biodiesel from food waste is gaining attention worldwide. Various types of food waste, including waste cooking oil, grease trap waste, and lipid-rich food waste, are being explored for biodiesel production. The extracted lipids are then purified to remove any impurities. During transesterification, extracted lipids are treated with alcohol (usually methanol or ethanol) in the presence of a catalyst to produce biodiesel.

Major challenges associated with biodiesel production from food waste include the variability in the composition of food waste, the need for efficient lipid extraction methods, and the need for effective catalysts for the transesterification process. Despite these challenges, the production of biodiesel from food was 5 Biogas. The process of converting food waste into biogas involves a set of microbiological reactions and

physico-chemical processes known as anaerobic digestion (AD).

Bioplastics—with notable progress in recent years, the field of producing bioplastics from food and agricultural waste is expanding quickly (Mandal et al., 2024). Bioplastics are biodegradable plastics that can be produced more cheaply and sustainably by using biological materials instead of petroleum. Utilizing agri-food waste as a substitute substrate for the production of biopolymers is one of the main areas of concentration in this research. For example, a well-studied strain of *Haloferax mediterranei* may produce polyhydroxybutyrate (PHB), a form of bioplastic, in high-salinity conditions without sterilizing (Bhattacharya et al., 2015).

Value-added products through hydrothermal treatment

Food waste can be used and hydrothermally treated to produce solid, liquid, and gaseous products. Formate can be made from food waste by hydrothermally carbonizing it; up to 78% of food wastes could be turned into formate. Formate is an excellent hydrogen storage carrier and battery material. Furthermore, the fluorescence properties and high compatibility of eggshells and carbon dots make them useful for photo catalysis, environmental monitoring, and biomedicine. Additional uses include multi-color from carbon dots hydrochar and hydroxyapatite recovered from pomelo peel that has characteristics similar to the structure of crystalline hydroxyapatite in human bones (Radulescu et al., 2022). Inexpensive graphene flakes made from leftover bread (Mokhtar et al., 2020). Hydrochar made from food waste has the potential to be a highly effective adsorbent for water contaminants. About 0.96% and 2.30% of fertilizers based on nitrogen and phosphorus, respectively, might be substituted with the hydrochar and liquid products made from food waste.

Additionally, food waste was effectively utilized as a resource by producing high-quality bio-oil by a hydrothermal treatment. Green biodiesel can be effectively produced using the hydrothermal liquefaction of waste edible oil. Through hydrothermal treatment, food waste can also be transformed into materials for industrial uses. For example, vegetable waste can be hydrothermally treated to produce acetic acid and calcium acetate, which can be used as a green deicing agent. According to study, the carbon-based Fe_3O_4 nanocomposite made from pomelo peel was also an effective fruit magnetic solid-phase extraction material. To create bioethanol, the chili post-harvest residue underwent fermentation and hydrothermal pretreatment with surfactants. Green biodiesel can be effectively produced by hydrothermally liquefying waste edible oil without the requirement for extra treatment procedures. Hydrothermal treatment of mango peel could achieve efficient extraction of pectin, a thickening agent (11.63%). Hydrothermal treatment helps with resource disposal and food waste reduction. Hydrothermal gasification of cellulose allows for the selective production of hydrogen at a comparatively low hydrothermal temperature. Finally, hydrothermal pretreatment of food waste can break down cellulose into simple substances such as glucose and can increase the ratio of protein to carbohydrate, which is beneficial for subsequent fermentation and other processing.

Food Waste Disposal and environmental effects of food waste

Food Waste Disposal and Classification is primarily divided into three categories: Volume Based Waste Fee (VBWF), Food Waste, and Recycling Waste. Food waste includes agricultural, fishery, and food leftovers generated during the production, distribution, and cooking processes. Recycling waste comprises plastics, cans, glass bottles, paper, and scrap metal, which should be sustainability leftovers generated during the production, distribution, and cooking processes. All other general waste is placed in VBWF garbage bags for disposal. The food waste separation rate is an indicator of the proportion of food waste that is collected separately rather than mixed with general waste. Therefore, it reflects the efficacy of the VBWF system.

The four metrics of global warming potential, nutritional enhancement, photochemical ozone production, and acidity are the major criteria used to assess the environmental impact of any method of disposing of food waste. When food is wasted rather than eaten, the environmental effects of food production and consumption are further com- pounded. Around 57.02 kg of CO_2-equivalent/tonne from anaerobic digestion and 18.3 kg CO_2-equivalent/tonne, through incineration of biogas waste was their respective contribution to global warming potential. Further, methane emission from both anaerobic digestion and in vessel composting leachate treatment processes constitutes a significant source of environmental burden for photo chemical ozone formation. Advancements in the biogas residue management process could reduce global warming potential.

New applications in food waste management

Mathematical models—Models are used to study the mechanics of anaerobic digestion, the engineering process, the parameters that affect biomethanation, and how they interact. Anaerobic digestion activity has been mathematically modeled and optimized using theoretical, empirical, and statistical methods. Digestion without air anaerobic digestion is classified as either liquid-state anaerobic digestion (L-AD) (TS ≤ 15%) or solid-state anaerobic digestion (SS-AD) (TS ≥ 15%) according to the total operational solid content. Solid loading capacity, increased volumetric biogas productivity, and lower energy requirements are the benefits of SS-AD. According to study during 2023, SS-AD systems are currently operated experimentally and lack mechanistic tools for process control. Application of statistically derived models can predict the system behavior and are especially useful when there are a limited number of targeting outputs. On the other hand, theoretical models provide more insight into the complex system mechanisms, while simplification is required to find general applications. AI-driven systems have demonstrated significant reductions in food waste, offering economic savings and environmental benefits.

Metagenomic Tools and Techniques for Advanced Practices:

Researchers have used a variety of 16S- and 18S-rRNA-based fragment studies to examine the microbiome and its diversity in the handling of food waste. Eukarya, Bacteria, and Archaea comprise the major microbial communities. There are 4133 methanogenic bacteria in the Archaea domain overall, with the most noticeable groups being Crenarchaeota and Euryarchaeota. Acetotrophic methanogens are the primary required anaerobes in the genus Methanosarcina that convert acetate into carbon dioxide and methane. Hydrogen-binding methanogenic bacteria belong to the Methanobacteriaceae family. The two primary families of hydrogenotrophic bacteria involved in the anaerobic digestion of fruit and vegetable wastes are Methanosphaera stadtmaniae and Methanobrevibacter wolinii. The knowledge of the link between taxonomical and functional diversity and species richness can be a key for better understanding of ecosystem functioning in waste food treatment. Molecular methods like PCR, RFLP, microarrays, and sequencing have been increasingly utilized in the field of waste management in the last decade.

Metagenomics—Ability of NGS to functionally characterize microbial communities on a large scale and its strength in studying collections of diverse microbes were demonstrated by the large-scale functional characterization of ecological systems captured through metagenomics. The use of this strategy in FW management can raise the caliber of management and treatment goods while also deepening our understanding of treatment. By investigating the available microbial resources and making strategic use of the latest metagenomics techniques, microbial communities can be employed in food waste management more effectively. Metagenomics research is aided by the development of sequencing and computing technologies, which expanded the reach of bioinformatics in microbial informatics and testing.

Microbial Community Analysis

Particularly at high organic load rates (OLRs), anaerobic digesters frequently experience a variety of instabilities related to inhibition, foaming, and acidification. The traits and dynamics of the microbial communities engaged in the anaerobic digestion process are typically linked to these instabilities. In order to maximize stable and effective process operations, microbial community analysis—which looks at the makeup and behavior of microbial communities—can be useful. New directions for studying microbial populations during anaerobic digestion have also been made possible by high-throughput sequencing technology. In their study of the microbial community for both single-phase and two-phase anaerobic digestion of Food waste. It is discovered that the two-phase continuous stirred tank reactor had a higher diversity of bacteria and a preponderance of Firmicutes resulting in a methane production that is 23% larger than that of single-phase anaerobic digestion. The archaeal community of single-phase and two-phase reactors was dominated by Methanosaeta. Using the Ribosomal Database Project classifier software categorization of the nucleotide sequences and demonstrated that the most prevalent microorganisms during the anaerobic digestion process were Proteobacteria, Firmicutes, and Bacteroidetes. The addition of Synergistetes, Tenericutes, Spirochaetes, and Actinobacteria during active methanogenesis resulted in a considerable increase in the variety of microorganisms compared to day 0. Using Illumina sequencing, it is examined how digestate recirculation affected the microbial population. The predominant bacterial phyla in both digester design types (with and without recirculation) were determined to be Proteobacteria, Firmicutes, Chloroflexi, and Bacteroidetes. Methanosaeta and Methanobacterium were dominant genera among the archaeal population, accounting for 65% and 32% of Euryarchaeota's reads in the mesophilic digester without recirculation, while, in the digester with digestate recirculation, Methanosaeta accounted for 91% of all Euryarchaeota.

Pulsed Electric Field (PEF) and Ultrasound-Assisted Extraction (UAE).

In recent years it has been shown that PEF is able to extract bioactive from a number of sources, generated vanillin, caffeine, and limonene yields improvements from agro waste such as cocoa shells and citrus peels. High purity β carotene and polyphenols in the carrot and tomato waste with minimum post processing was recovered from UAE.

Other hybrid methods include the Enzyme assisted microwave extraction utilizes enzyme pretreatment which specifically degrades plant cell wall components followed by microwave assisted extraction that increases the release of intracellular compounds by localization heat and pressure. The hybrid strategy is specifically applicable for agro-wastes containing substantial lignocellulosic such as rice bran, wheat straw, and fruit pomace. The Ohmic Heating Combined (OH) with Solvent-Free Extraction is the method of passing electric current through moist biomass and generating internal heat due to electrical resistance of the sample. Researchers during 2022 used this method on olive mill wastewater (OMWW) and recovered high purity hydroxytyrosol and tyrosol at 60–70 °C.

Discussion

Food waste has become a global scourge that requires actionable and innovative solutions to combat the scourge and its attendant effects. These staggering figures within the food system are an indication on its social, economic, and environmental impacts requiring intervention. Food waste has been reported to account for 8–10% of global greenhouse gas emissions with attendant negative impact on farm produce yield, nutritional quality, and food supply chain disruption. The SDG 12 underscores the importance of responsible food consumption and waste reduction/management to promote the sustainable food production agenda (sdgs/un). The initial important steps therefore, are approaches and policies geared towards waste repurposing and upcycling and fostering effective food resource management. Waste upcycling strategies are a circular bio-economy allowing food waste to be repurposed by converting food waste biomass into a value-adding product or ingredients. These products can be consumed directly or used as platform products as raw materials for other consumer products. Several methods have been available to treat food waste, including food donation, animal feed, composting, thermal or biological conversion, or landfilling. Each of these methods is based on the substrate and their inherent treatment procedure and capacity. For example, landfilling represents the dominant method (35%) of food waste treatment. Alternatively, methods include pyrolysis, which has negative carbon emission footprints. Advantage of thermal treatment method in the absence of oxygen and the byproduct solid char with high carbon content can be stored, utilized as energy or soil additive. Several innovations and scope for research are needed in each of these methods to scale-up the method of food waste treatment. The present trend in cooking is the high dependence on firewood for cooking in villages and fossil fuels in towns and cities. AD of manure and crop residues can substitute 50-60% of final energy for cooking in villages and about 10% of final energy for cooking in towns and cities. Additional financial support through Research, Development and Demonstration programme will provide impetus at the resource levels. Compost and digestate play minor roles in comparison to fertilizers in India (et al., 2023), thus encouraging small- to medium-scale composting and AD plants should be promoted. Local participation, NGO and combined initiatives and of provision of affordable/dry, free land will also promote food management at the community level. As a result of incorrect and common food disposal practices, which have detrimental environmental effects, a significant amount of greenhouse gas (GHG) emissions and foul odor discharge occur. India produces a lot of food waste, but its techniques for disposing of it are quite inadequate; instead, organic garbage is typically dumped at landfills. Landfills are the most common method of food waste disposal in developing nations including India, which accounts for approx. 90% of the total food waste. But this practice is not encouraged in reality due to its increased probability of producing disease vectors and releasing greenhouse gases. Plausible solution includes Manure and crop residues (20-40%) are abundant in villages and still mostly untapped as energy source of crop residues remain unused as animal feed or fertilizer. Their collection and treatment may be feasible in some places, especially with water-saving dry AD. It is highlighted the feasibility of green vehicles running using green energy produced from food wastes in near future. There have been proposals for internal combustion engine cars (ICEVs) powered by biomethane and bioethanol, fuel cell vehicles (FCVs) powered by biohydro gen, and plug-in electric vehicles (PEVs) powered by bioelectricity. These efforts will contribute towards sustainability.

It is noteworthy to note from the increased number of publications that globally several research and private firms are showing interest in this area of food chain and government policies and legislation indicating the concern to minimize food waste. Microbial ecological analysis in the near future will need a paradigm shift from data generation and management to innovative and hypothesis driven research. Application of new microbial sources to facilitate treatment through Genetic engineering, metagenomics and high-through put methods is required to enhance the out-put at several levels. Further, *in silico* generated knowledge coding, mining, and networking will aid new knowledge discovery to attain sustainable food waste management. Judicious use of food at source in the society at several levels in the food chain, home, hotels, universities contribute immensely to reducing food waste at source. Second systematic management of food waste through proper inventory, redistribution of unused food and conscious use of food products will lower the waste. Awareness of environmental pollution and initiatives such as the 'Swachh Bharat (clean India) Mission' will help create wider awareness through audio-visual, print media. Awareness through Gram-panchayath and taluk level will promote better waste management. Thus the collective efforts of public, private and several allied food chain sectors along with policies and awareness will ensure reduction and management of global food waste.

References

1. Roe BE, Bender K, Qi D (2021) The impact of COVID-19 on consumer food waste. Appl Econ Perspect Policy 43 (1): 401-411.
2. Ristic D, Bender D, Jaeger H (2024) Towards a definition of food processing: conceptualization and relevant parameters. Food Prod Process and Nutr 6(1):79.
3. Lam CM, Yu IKM, Hsu SC, Tsang DCW (2020) Life-cycle assessment of food waste recycling. Waste Biorefinery. In: Bhaskar T, et al. (Eds.), Elsevier, pp: 481-513.
4. Paritosh K, Kushwaha SK, Yadav M, Pareek N, Chawade A, et al. (2017) Food Waste to Energy: An Overview of Sustainable Approaches for Food Waste Management and Nutrient Recycling. BioMed Research International (1): 2370927.
5. Yahia EM, García-Solís P, Celis MEM (2019) Chapter2 - Contribution of Fruits and Vegetables to Human Nutrition and Health. In: Elhadi M, (Eds.), Postharvest Physiology and Biochemistry of Fruits and Vegetables, Woodhead Publishing, pp: 19-45.
6. Baykoca B, Yılmaz S (2025) Understanding food loss patterns across developed and developing countries using a GDP, growth rate, and health expenditure-based typology. Sci Rep 15 (1): 27597.
7. Guggisberg S (2021) Transparency in the activities of the food and agriculture organization for sustainable fisheries Marine Policy. Article 136: 104498.
8. Tonini D, Albizzati PF, Astrup TF (2018) Environmental impacts of food waste: learnings and challenges from a case study on UK. Waste Manag 76: 744-766.
9. Balaji M, Arshinder K, (2016) "Modeling the causes of food wastage in Indian perishable food supply chain,". Resources, Conservation & Recycling, Elsevier, 114: 153-167.
10. Di Marcantonio F, Twum EK, Russo C (2021) Covid-19 pandemic and food waste: an empirical analysis. Agronomy 11(6): 1063.
11. Pappalardo G, Cerroni S, Nayga RM, Yang W (2020) Impact of Covid-19 on household food waste: the case of Italy. Front Nutr 7: 585090.
12. Al-Rumaihi A, McKay G, Mackey HR, Al-Ansari T (2020) Environmental Impact Assessment of Food Waste Management Using Two Composting Techniques. Sustainability 12(4): 1595.
13. Fava F, Totaro G, Diels L, Reis M, Duarte J, et al. (2015) Biowaste biorefinery in Europe: opportunities and research & development needs. New Biotechnology 32(1): 100-108.
14. Sinha S, Tripathi P (2021) Trends and challenges in valorisation of food waste in developing economies: a case study of India. Case Stud Chem Enviro Eng 4: 100162

Designing Rising Mains in Highrise Residential Buildings

B Manjunath
Director

Understanding Why Simultaneous Fixture Demand Governs Over LPCD ?

High-rise residential water supply design requires careful differentiation between two fundamentally different approaches:

1. Population-based water demand (LPCD method)
2. Simultaneous fixture usage (Hunter method)

While both are essential, applying them incorrectly can result in undersized rising mains, pressure imbalance, and operational instability.

This article demonstrates the engineering implications using a 24-storey residential building case study.

Project Overview

- 24 Storeys
- 4 Flats per floor (96 total)
- Floor-to-floor height: 3 m
- Total height: 72 m
- Occupancy: 5 persons per flat
- Water demand: 90 LPCD
- Consumption window: 8 hours
- Peak factor: 3
- Pressure limits: 1 bar (min), 3.5 bar (max)
- Max velocity: 1.5 m/s
- System: Common rising main with hydropneumatics system

Each flat contains:

3 Toilets (WB + Shower + HF), Kitchen (Sink + RO), Utility (Sink + WM)

Method 1 : Simultaneous Fixture Method (Hunter Curve)

Total calculated fixture load ≈ **1776 WSFU**

Hunter curve conversion:

Design flow **≈ 5.36 L/s**

Rising Main Selection

At velocity limit 1.5 m/s:

Required diameter ≈ 67 mm

Selected standard size: **DN80**

Velocity in DN80 ≈ 1.06 m/s (within limits)

Pump Requirement

Static head: 72 m

Minimum pressure at top: 10 m

Friction losses: ≈ 10 m

Total dynamic head **≈ 92 m**

Pump duty: 5.36 L/s @ 92 m

Method 2: LPCD + Peak Factor

Total population	Daily demand	Average flow (8 hrs)	Peak factor	Peak demand
480 persons	43.2 m³	1.5 L/s	3	4.5 L/s

Critical Comparison

Parameter	Hunter	LPCD
Design Flow	5.36 L/s	4.5 L/s
Governing Method	Hunter	–

Hunter demand governs pipe sizing.

Pressure Engineering Challenge

Single 72 m riser produces bottom pressure ≈ 8 bar, exceeding allowable 3.5 bar.

Therefore, pressure zoning is mandatory.

Recommended Zonal Design

C	Floors	Height	Pump Head
1	1 - 8	24 m	~ 45 m
2	9 - 16	24 m	~ 45 m
3	17 - 24	24 m	~ 45 m

Advantages:

- Maintains pressure within limits
- Improves energy efficiency
- Prevents system overstress
- Enhances long-term reliability

Engineering Conclusion

LPCD governs storage.

Hunter governs pipe sizing.

Pressure zoning governs safety.

Understanding these distinctions is critical for designing resilient high-rise water supply systems.

Gravity and Hydro-Pneumatic Water Supply Systems A Public Health Engineering Perspective

Lakshmi M
Technical Director - PHE

Introduction

Water supply system design is a critical component of Public Health Engineering, directly impacting public health, user comfort, and building functionality.

As per **NBC 2016 (Part 9 – Plumbing Services) and CPHEEO Manual on Water Supply**, the system must ensure adequate quantity, pressure, quality, and continuity of water supply to all plumbing fixtures within a building. Whether a Gravity System or a Hydro-Pneumatic (Pressure Booster) System is adopted, the fundamental objectives remain the same—public health safety, hydraulic adequacy, and operational reliability

Gravity Water Supply Systems and Hydro-Pneumatic Systems are governed by common design principles, standards, and codes. The selection depends on building height, demand pattern, pressure requirements, energy efficiency, and operation & maintenance considerations.

Applicable Codes and Standards

The following standards apply to both gravity and hydro-pneumatic water supply systems:

- NBC 2016 – Part 9 (Plumbing Services)
- CPHEEO Manual on Water Supply and Treatment
- IS 2065 – Water supply in buildings
- IS 10500 – Drinking water quality
- Local municipal water supply by-laws

These codes ensure uniformity in design, safety, water quality, and system performance irrespective of the type of distribution system used.

Requirements for Water Supply Systems

Water Demand and Storage

Water demand calculation for both systems is carried out as per **NBC and CPHEEO norms,** based on:

- Building occupancy and usage
- Per capita water demand
- Peak demand factors

Pressure Requirements

The pressure at any point depends on the height of the water column above that point, generally calculated as:

Pressure (kg/cm²) ≈ Height of water column (m) / 10

As per **NBC guidelines,** the system must ensure:

- Minimum residual pressure of **0.5 kg/cm²** at the farthest and highest fixture.
- Maximum pressure of **3.5 kg/cm²** to avoid fixture damage (Not mentioned in NBC)
- Use of pressure-reducing valves where required

Pressure zoning may be adopted for taller buildings.

Velocity

- The NBC 2016 Part 9 does not explicitly state a minimum velocity requirement in the water supply design clauses.
- In plumbing design practice, a minimum design velocity of around 0.6–0.9 m/s is often used to ensure self- cleansing and prevent sedimentation in distribution pipelines.
- As per NBC guidelines, the recommended maximum permissible velocity of water in distribution pipes is 2.4 m/s.

1. Gravity Water Supply System

Working Principle

The gravity system operates on a simple and time-tested principle: water flows under gravity from a higher elevation to a lower elevation. Water is pumped to an overhead tank (OHT) or elevated reservoir, from where it is distributed to fixtures through vertical down-take pipes. In a gravity water supply system, water is first pumped from an underground sump or ground-level reservoir to an overhead water tank (OHT). From the OHT, water is distributed to various plumbing fixtures through vertical down-take pipes, flowing solely under the force of gravity.

Figure 1&2 illustrates the typical flow diagram & schematic layout of a gravity water supply system.

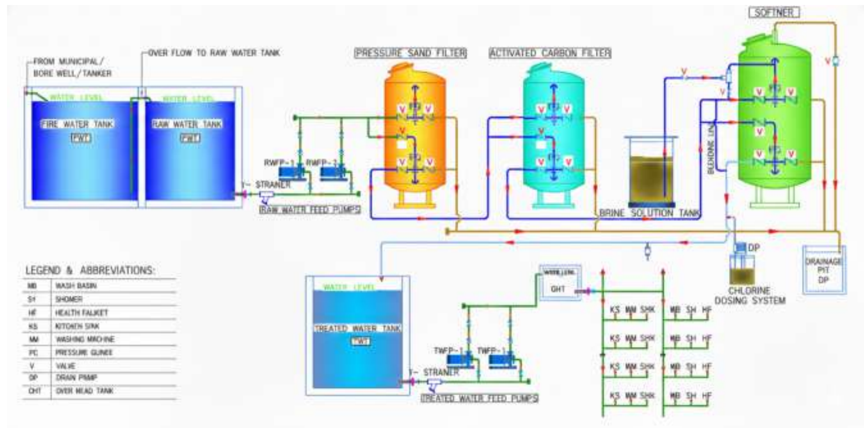


Fig 1: Typical flow diagram of a Gravity Water Supply System

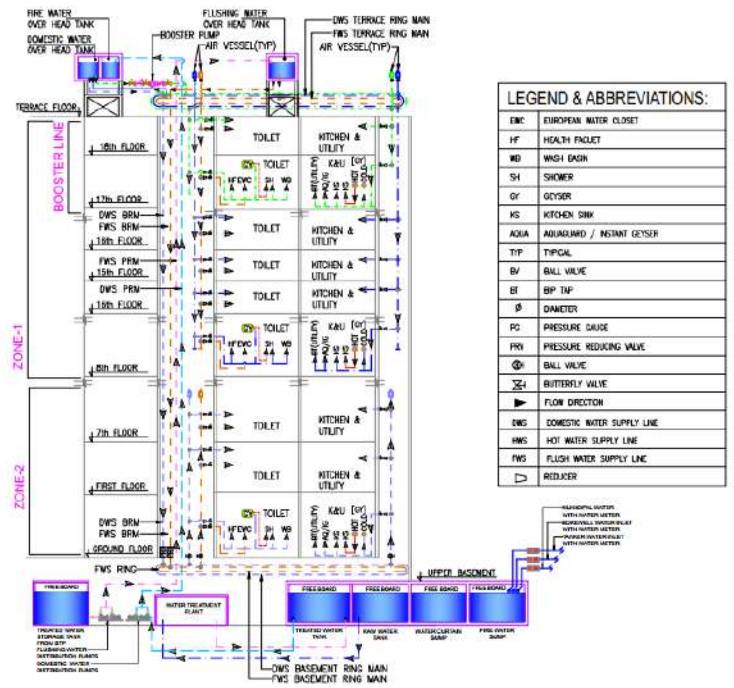


Fig 2: Typical schematic of a Gravity Water Supply System

Key Components

- Underground sump or ground-level reservoir
- Pumping system (Working + standby)
- Overhead water tank
- Distribution piping and valve

Advantages

- High reliability: Water supply continues even during power failure (until OHT is empty)
- Simple operation and maintenance
- Low operational cost compared to pressure systems
- Minimal mechanical dependency
- Suitable for residential buildings and low to mid-rise structures

Limitations

- Requires additional structural load for overhead tanks
- Pressure variation between lower and upper floors
- Aesthetic concerns due to visible tanks
- Potential water stagnation if tanks are oversized or poorly maintained
- Not ideal for high-rise buildings without pressure zoning

Typical Applications

- Residential buildings
- Schools and hostels
- Small hospitals
- Commercial buildings
- Rural and semi-urban water supply schemes

2. Hydro-Pneumatic Water Supply System

Working Principle

In a Hydro-pneumatic water supply system, water is delivered to plumbing fixtures at a controlled and nearly constant pressure using booster pumps and pressurized vessels, eliminating the need for an overhead tank. Water stored in an underground tank is pumped into the distribution network, while a pressure vessel containing compressed air acts as a cushion to maintain system pressure.

Pressure sensors, control panels, and variable frequency drives (VFDs) automatically regulate pump operation based on demand, ensuring uniform pressure across all floors and fixtures.

Fig 3 & 4 illustrates the typical flow diagram & schematic layout of a Hydro-Pneumatic Water Supply System.

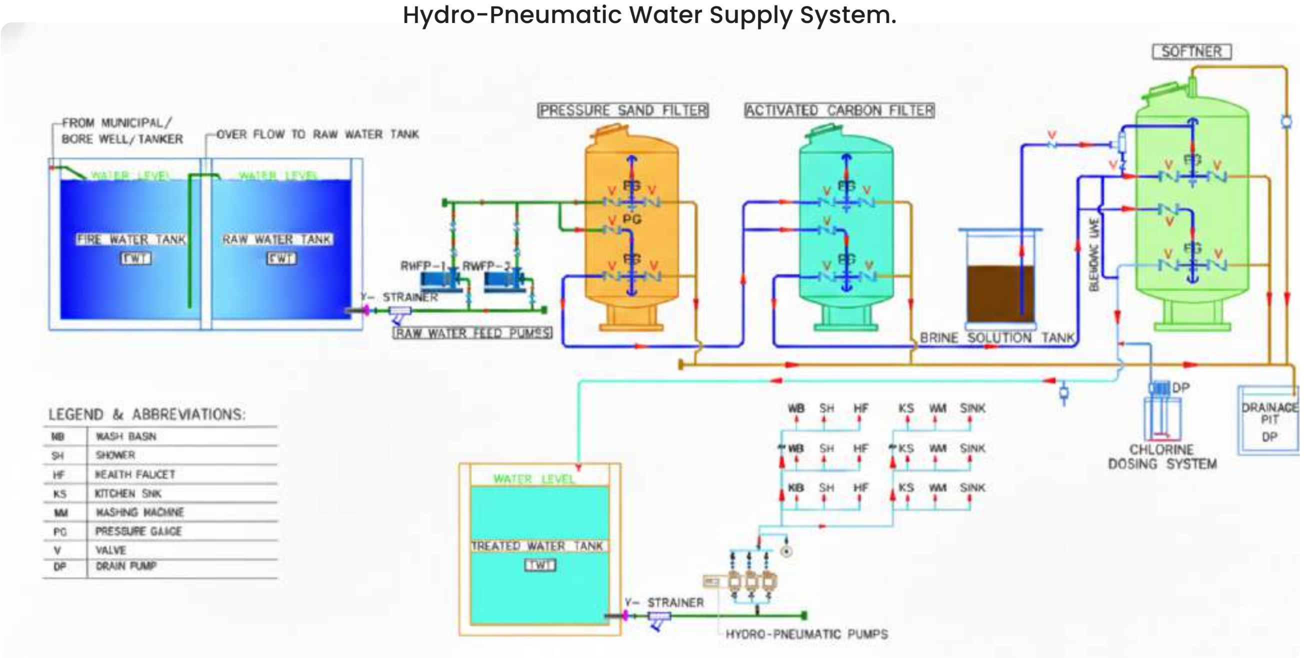


Fig 3: Typical flow diagram of a Hydro-Pneumatic Water Supply System

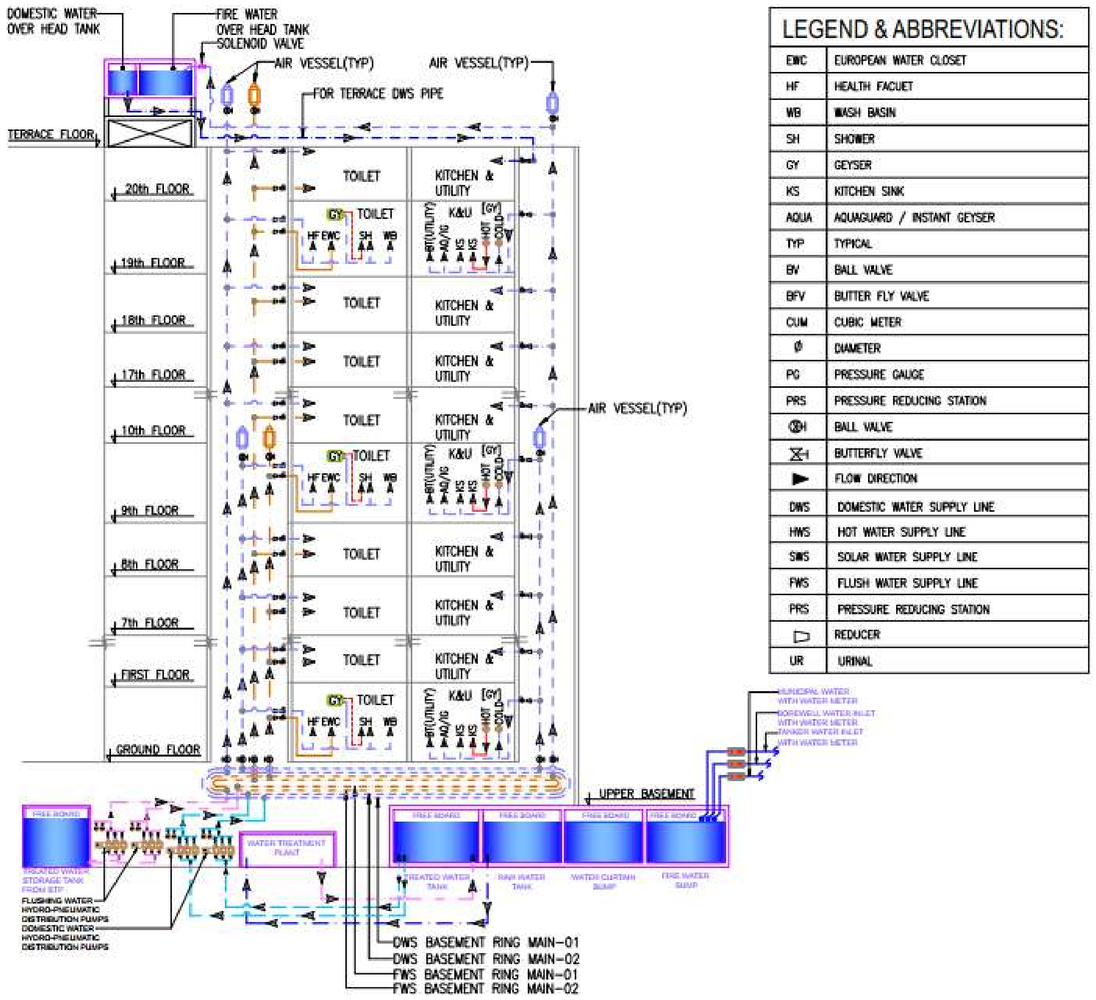


Fig 4: Schematic of a Hydro-Pneumatic Water Supply System

Key Components

- Water storage tank (underground)
- Booster pumps (with VFD)
- Pressure vessels (diaphragm or bladder type)
- Control panel with pressure switches and sensors
- Distribution piping network

Advantages

- Uniform pressure across all floors
- Eliminates need for overhead tanks
- Saves roof space and improves building aesthetics
- Ideal for high-rise buildings
- More hygienic due to reduced stagnation
- Easily adaptable to automation and monitoring systems

Limitations

- Higher initial capital cost
- Continuous dependency on power supply
- Requires skilled operation and regular maintenance
- Mechanical and electrical components increase system complexity
- Standby power (DG/UPS) is essential for reliability

Typical Applications

- High-rise residential and commercial buildings
- Hotels and shopping malls
- Airports and IT parks
- Hospitals requiring controlled pressure
- Premium and smart buildings

3. Comparison at a Glance

Parameter	Gravity System	Hydro-Pneu-matic System
Pressure control	Variable	Constant
Power dependency	Low	High
Capital cost	Low	High
Maintenance	Simple	Skilled
Suitability	Low to mid-rise	Mid to high-rise
Overhead tank	Required	Not required
Automation	Limited	High

4. Design Considerations for PHE Engineers

When selecting between gravity and hydro-pneumatic systems, the following factors must be carefully evaluated:

- Building height and usage
- Water demand and peak factors
- Availability and reliability of power supply
- Operation and maintenance capability
- Life-cycle cost rather than only initial cost
- Local regulations and client preferences
- Fire-fighting and emergency requirements

In many large developments, a **hybrid approach** is adopted, combining gravity systems for domestic supply and hydro-pneumatic systems for specific zones.

Conclusion

Both gravity and hydro-pneumatic water supply systems have their rightful place in modern building services engineering. The gravity system re- mains a robust, economical, and dependable solution, while hydro-pneumatic systems offer superior pressure control, space efficiency, and modern automation.

Our responsibility lies in **selecting the right system for the right application**, ensuring public health safety, operational efficiency, and sustainability. A well-designed water supply system not only supports building functionality but also contributes significantly to user comfort and long-term asset value.

Methodology Integrated Lightning Protection System with Equipotential Bonding as per NBC 2016, IS 3042 & IS/IEC 62305

Soumya D U
Associate Technical Director - Electrical

GENERAL

An effective earthing and lightning protection system is essential to safeguard buildings, occupants, and equipment against electrical faults and lightning discharges. A common integrated earthing system shall be designed and installed to serve both the electrical earthing system and the lightning protection system (LPS), ensuring equipotential bonding throughout the structure.

The earthing system shall comprise:

- Earthing electrodes
- Earth conductors
- Equipotential bonding conductors
- Earth bars / earth stud terminals
- Down conductors and air termination network

All components shall be electrically continuous, mechanically robust, and corrosion resistant.

OBJECTIVES OF EARTHING & LIGHTNING PROTECTION

The earthing and lightning protection system shall aim to:

- Provide a low impedance path for fault and lightning currents
- Ensure equipotential bonding of all exposed and extraneous conductive parts
- Minimize the risk of fire and equipment damage
- Protect personnel by limiting step and touch voltages
- Safely dissipate lightning and short-circuit currents into the ground
- Provide a stable reference potential for sensitive electronic and communcation equipment.

TYPES OF LIGHTNING PROTECTION SYSTEM

A. Integrated lightning protection system with equipotential bonding (below pcc) Design components include:

1. Underground earth mesh
2. Exothermic welded joints
3. Riser conductors (earthing & LPS)
4. Riser extensions
5. Earth stud terminals
6. Air termination system
7. Concrete flat roof conductor holders
8. Cross connectors and expansion joints
9. Vertical air terminals
10. Earth studs at parapet level

B. Integrated lightning protection system with equipotential bonding (above pcc) Design components include:

1. Mesh integrated with reinforcement (rebar)
2. Common earthing system
3. Air termination systemExternal lightning protection system

C. External Lightning Protection System Design components include:

1. Air termination system
2. Down conductor system
3. Earthing system

Elements of Earthing & Lightning Protection:
Earth Mesh (Below Ground)

- 8 mm copper-bonded round conductor shall be straightened on site using a bending lever.
- Conductors shall be laid in soil as per approved drawings.
- All straight, T, and cross joints shall be exothermically welded to ensure permanent electrical continuity.

EXOTHERMIC WELDING
Safety Requirements

- Leather gloves, goggles, mask, and general PPE are mandatory.

Procedure

- Appropriate mould, handle, gun, and welding powder shall be used as per joint type.
- Mould shall be preheated to 70°C–100°C.
- Conductors shall be preheated to 30°C–50°C.
- Welding powder and ignition powder shall be placed as specified.
- Ignition shall be carried out carefully, ensuring firm holding of the mould.
- After cooling (10–15 seconds), the mould shall be removed and cleaned thoroughly.

RISER (Equipment Earthing and Lightning Protection System)

- Required conductor length shall be measured and cut from the coil.
- 10 mm copper-bonded round conductor shall be fixed along reinforcement bars using bonding clamps.
- Connection to underground mesh shall be by exothermic welding.
- Riser conductors shall be extended from bottom to terrace level.
- Bonding clamps shall be provided at every 2–4 m, and binding wire at 300 mm intervals.
- Conductors shall remain straight and in continuous contact with rebar.

EARTH STUD TERMINAL

Earth studs shall be installed at designated locations such as:

- LV & ELV shafts
- Electrical rooms
- Lift machine rooms
- Terrace parapet
- Stainless steel earth stud shall be bonded to rebar and 10 mm copper-bonded conductor using bonding clamps.

- Protective green covers shall be fixed to prevent ingress of concrete.

AIR TERMINATION SYSTEM

- Parapet locations shall be marked and holes drilled at 1 m intervals.
- Parapet conductor holders shall be fixed using dowels.

- 8 mm aluminium round conductor shall be straightened and installed.
- Sharp bends shall be avoided at corners.
- All exposed metal parts shall be bonded to the air termination system using suitable clamps.

CONCRETE FLAT ROOF CONDUCTOR HOLDER

Conductor routes shall be marked as per approved drawings.

- Concrete holders shall be fixed at 1 m intervals using cement mortar.
- Aluminium conductors shall be straightened and laid securely.
- Expansion joints shall be provided at every 20 m using approved expansion pieces.
- Cross and T joints shall be connected using SS cross connectors.

Every 20mtr Expansion piece should be connected with the 8 mm Aluminium conductor. Connection shall be of straight conductor connector.

Cross/T joint should be clamped with SS cross connector

VERTICAL AIR TERMINAL

- Locations shall be finalized after completion of terrace conductor layout.
- Concrete bases shall be fixed using cement slurry.
- Vertical air terminals with interception tips shall be installed.
- VATs shall be interconnected with terrace aluminium conductors using SS cross connectors.

EARTH STUD @ PARAPET

- Aluminium conductors or vertical air terminals shall be connected to parapet-mounted earth studs to ensure continuity between roof and down conductors.

MESH IN REBAR

- 10 mm copper-bonded conductor shall be laid within reinforcement.
- Bonding clamps shall be provided at 2–4 m intervals.
- Binding wire shall be fixed at 300 mm spacing.
- Cross/T joints shall be connected using cross connectors.
- Straight joints shall use straight connectors.

- Riser extensions shall be taken through columns as per drawings.

EARTHING SYSTEM

10 mm Copper coated conductor After test joint 10mm copper coated conductor is laid vertically on the side wall. At every 1meter conductor holder is used for holding round conductor. Before laying, 10 mm conductor should be straightened by using Lever.

Type A Earthing

- Individual earth electrodes connected to each down conductor.
- Electrodes shall be installed at a minimum depth of 3 m.
- Horizontal electrodes, where used, shall be twice the vertical length.
- Connections shall preferably be exothermically welded.

Type B earthing

- Closed-loop ring earth electrode or foundation earth electrode.
- Buried at a minimum depth of 0.5 m and 1 m away from the building.
- At least 80% of conductor length shall be in contact with soil.
- Open loops shall be treated as Type A earthing.

DOWN CONDUCTOR SYSTEM

Aluminium round conductor

- Aluminium round conductors shall be straightened and installed vertically along sidewalls.
- Conductor holders shall be fixed at 1 m intervals using screws and plastic dowels.
- Number of down conductors shall be as per the required Lightning Protection Level (LPL).

Conductor Holder

Is fixed over the side wall vertically by drilling at every 1 meter and it is fixed with the use of Screw & plastic dowel. This is for holding aluminium conductor vertically. Number of down conductors is selected based on the level of protection.

- Make a straight line in sidewall
- Drill holes at every 1 meter
- Fix conductor holder in these drilled holes
- Fix the straight conductor inside the clip

Lightning Strike Counter

- Lightning counter shall be installed on the down conductor.
- Mounted at 1.2 m above Finished Floor Level (FFL).
- Records date, time, and number of lightning events.

TEST JOINT WITH ENCLOSURE

- Test joint shall be provided for interconnection between:
- 8 mm aluminium conductor
- 10 mm copper-bonded conductor
- Installed at 1.0 m above FFL.
- Test joint shall be housed in an IP65-rated enclosure.

COMPLIANCE

All materials, workmanship, and installation practices shall strictly comply with:

- NBC 2016
- IS 3043 – Code of Practice for Earthing
- IS/IEC 62305 – Protection Against Lightning

Fire Detection System

Gowrish S B
Technical Director - F&Ls

Why do we need fire detection system in our buildings?

Fire detection systems aren't just a regulatory box to tick — they're one of the most important layers of protection in any building. When you think about how quickly a small spark can turn into a life threatening situation.

Given below is an explanation of the system, and why every building needs a fire detection system.

What makes fire detection systems essential?

Early warning for occupants:

Fires spread fast. A detection system alerts people immediately so they can evacuate before smoke and flames become overwhelming.

Prevention of property damage:

"The sooner fire is detected, the sooner it can be controlled". Early detection often means the difference between a small incident and a total loss.

Automatic activation of safety systems:

Fire alarms can trigger sprinklers, smoke control systems, emergency lighting, and even shut down HVAC to prevent smoke spread.

Compliance with building codes and insurance requirements:

Most jurisdictions, Codes and Guidelines require fire detection systems in residential, commercial, hospital, hotel, assembly developments and industrial buildings. Insurance companies also expect them to reduce risk.

Protection of highvalue assets and critical infrastructure:

Data centers, hospitals, factories, and offices rely on uninterrupted operations. Fire detection helps safeguard equipment and essential services.

Safety while sleeping or high occupancy environments places:

Like apartments, hotels, schools, and malls need reliable detection because people may not notice a fire until it's too late.

Peace of mind for building owners and occupants:

knowing the building is monitored 24/7 reduces anxiety and ensures a safer environment for everyone.

Algorithms Multicriteria detection system For RESIDENTIAL, Hospital & Retail Buildings

Why multicriteria detectors are used and what technical advantages detectorbased algorithms provide, to use algorithms.

Multicriteria detector contains multiple sensing elements inside one housing. These may include:

- Optical smoke sensing — detects smoke particles

- Heat sensing — detects temperature rise
- CO sensing — identifies carbon monoxide from smouldering fires
- Flame/light sensing — detects flame flicker or light signatures

Multicriteria detectors use algorithms to analyse data from all sensors together. This gives them several advantages:

- Reduced false alarms — less triggered by steam, dust, cooking fumes, or aerosols
- Faster and more accurate fire detection — because they detect multiple fire signatures simultaneously
- CO lifesafety detection — electrochemical CO sensors provide separate CO alerts
- Better immunity to nuisance particulates — advanced processing improves reliability

Why we have to use Multicriteria detectors and what is the technical benefit of using detectors use algorithms

The technical benefits of using detectors that rely on algorithms, especially in fields like computer vision, cybersecurity, signal processing, and industrial automation.

a. Higher Accuracy

- Pattern recognition algorithms can detect subtle features that humans or simple rules would miss.
- Machine learning based detectors improve accuracy over time as they learn from data.

b. Real Time Processing

- Fast computational algorithms allow systems to detect events, objects, or anomalies instantly.
- Essential for applications like autonomous driving, fraud detection, and intrusion detection.

c. Scalability

- Algorithmic detectors can handle massive data streams without performance loss.
- Ideal for large networks, IoT systems, and big data environments.

d. Consistency and Reliability

- Automated detection logic eliminates human error and fatigue.
- Produces stable, repeatable results across millions of operations.

e. Advanced Feature Extraction

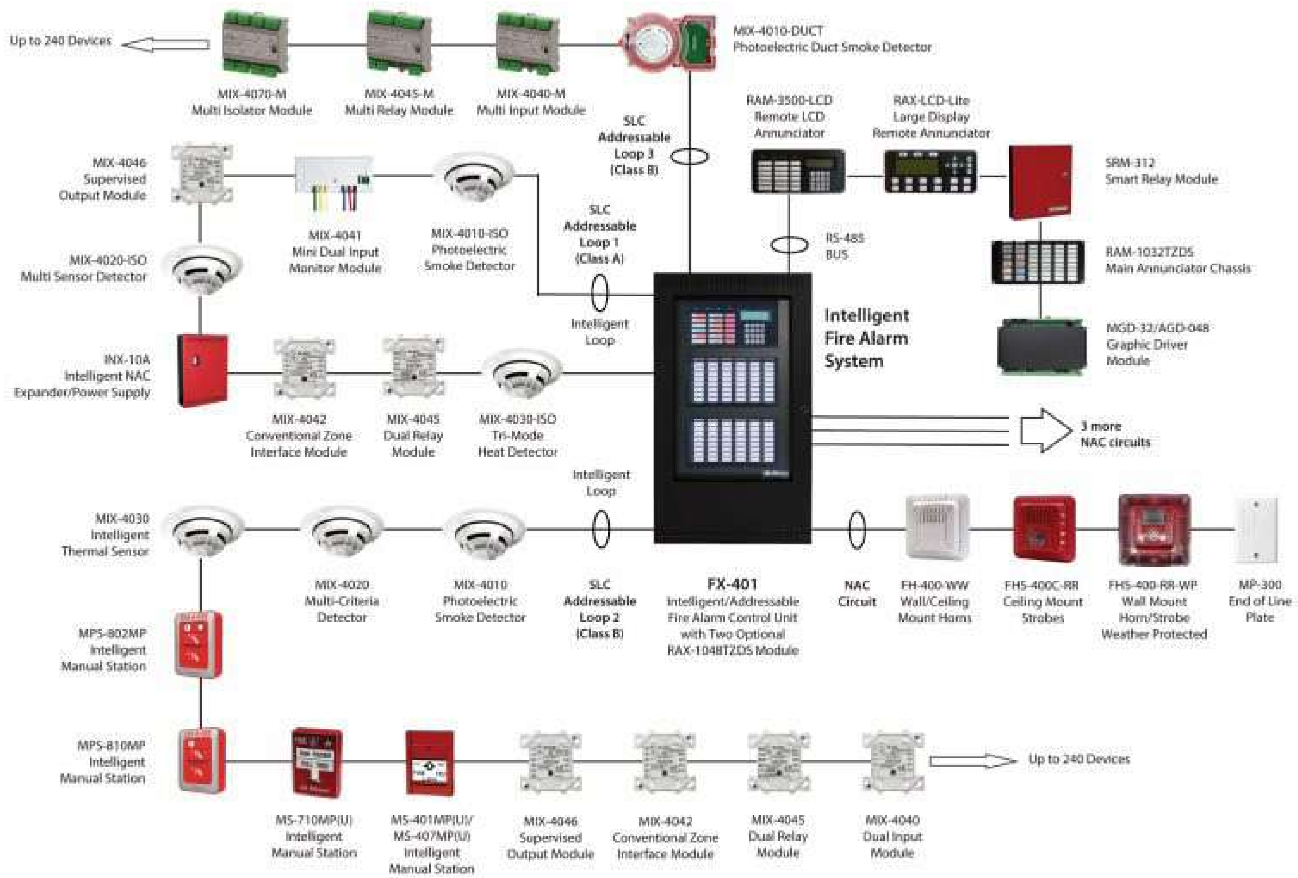
- Signal processing algorithms can isolate meaningful patterns from noisy data.
- Useful in medical imaging, radar, audio analysis, and more.

f. Adaptability and Learning

- Machine learning detectors can adapt to new threats, objects, or patterns without manual reprogramming.
- Crucial for cyber security and evolving environments.

g. Cost Efficiency

- Automated detection systems reduce the need for manual monitoring.
- Lower operational costs and faster decision making.



High Rise Building Design - Pumping System

Madhu Chandrashekar
Technical Director – HVAC

In tall buildings, static (hydrostatic) pressure due to vertical water column is a major driver in how you design water distribution systems (chilled-water, hot-water, condenser water, etc.).

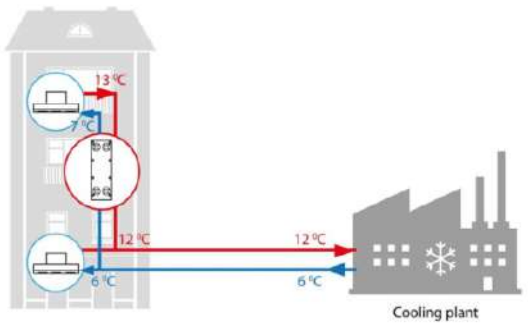
Specifically for chilled-water systems: the combined static + dynamic (pump) pressure at any point must remain within the working pressure rating of pipes, valves, coils, heat-exchangers, and other equipment.

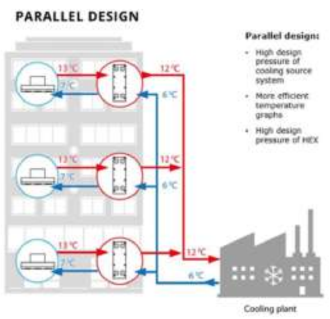
For very tall buildings, the standard recommendation (in the reference guide for "tall/supertall/mega-tall" buildings) is to split the building into multiple static-pressure zones, separated by pressure-breaks (typically by means of plate-and-frame heat exchangers, or "decouplers") located at mechanical (Technical) floors.

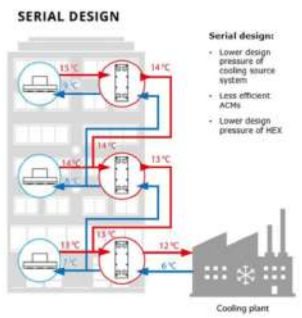
The number of zones is decided based on the total building height and the maximum allowable working pressure of the system. For instance, in an example in the literature, a 160 m building shall split into TWO zones so that each zone handles roughly HALF of total static head. 220 M shall spilt into THREE zones.

The pumps for each zone — whether primary (chiller-side), or secondary (zone distribution) — should be configured carefully. For example, locating the CHW pumps on the discharge (i.e., downstream) side of the evaporator or heat exchanger helps reduce the net pressure on the chiller and its internal water boxes.

Your two-zone design (≈ 80 m per zone) is consistent with this approach: it limits static head per zone to a manageable level, avoids excessive over-pressurization of coils/valves/equipment, and keeps riser pressures under control.







Establish Equipment / Piping Pressure Ratings

For a 160 m building, the chilled water network is usually split into multiple vertical pressure zones using plate heat exchangers and zonal pumps so that no loop exceeds the pressure rating of pipes, valves, or coils, while highΔT and variable flow minimize pumping energy. A good practical approach is a primary "express" loop from the main plant feeding two or three secondary loops located at mechanical floors.

Stepwise design approach

Determine allowable working pressure of equipment (often 10–16 bar for piping, 10–15 bar for coils/valves) and translate that into maximum vertical height per zone using 1 bar ≈ 10 m water column, then add friction margin.

For 160 m, two zones of roughly 80 m each are common; position Mechanical / Technical floors accordingly and place plate heat exchangers to hydraulically isolate zones while transferring cooling from the primary loop.

Hydronic configuration and energy minimization Use a variable primary or primary–secondary configuration with VFD pumps and differential pressure control at critical coils to reduce pump power under part load.

Design for higher ΔT (for example 8–10 K at design) to reduce flow rate, pipe sizes, and pump head, ensuring coil selection and control strategy avoid low-ΔT syndrome.

Zonal loops and controls

Each zone has its own distribution pumps, expansion vessel, Pioneer Urban, Gurugram and headers feeding local AHUs/FCUs via short risers, which limits static pressure and simplifies balancing.

Optimize pump head by careful pipe routing, modest design velocities, and actively reset differential pressure and chilled water temperature setpoints based on load and valve positions Determine max allowable working pressure for your pipes, valves, coils, heat-exchangers, fan-coil / AHU coils etc (e.g., many systems for chilled

water are rated for ~10–16 bar or so depending on spec).

Translate that into maximum vertical height (static head) permitted for a zone, allowing margin for friction and dynamic head. Recall approximate relation: ~1 bar ≈ 10 m water column (plus friction & pump head).

Define Number of Zones & Location of Mechanical Floors

For 160 m total height, two zones (~80 m each) is reasonable and standard; place mechanical / technical floors accordingly (near ~80 m).

Install plate-and-frame (or plate-and-shell) heat-exchangers at the zone boundaries to hydraulically isolate the upper-zone loop from the primary express riser.

Decide on Pumping Strategy

Use primary (plant-side) pumps for the feeding of the chillers.

On the secondary side (each zone), use dedicated CHW distribution pumps (with VFDs) to feed the local AHUs / FCUs / Plate heat exchange.

Tertiary Pumps with VFD to feed the higher zone.

Use VFD + differential-pressure control (or variable-flow pumping) to optimize energy usage and avoid “over-pumping” under partial load.

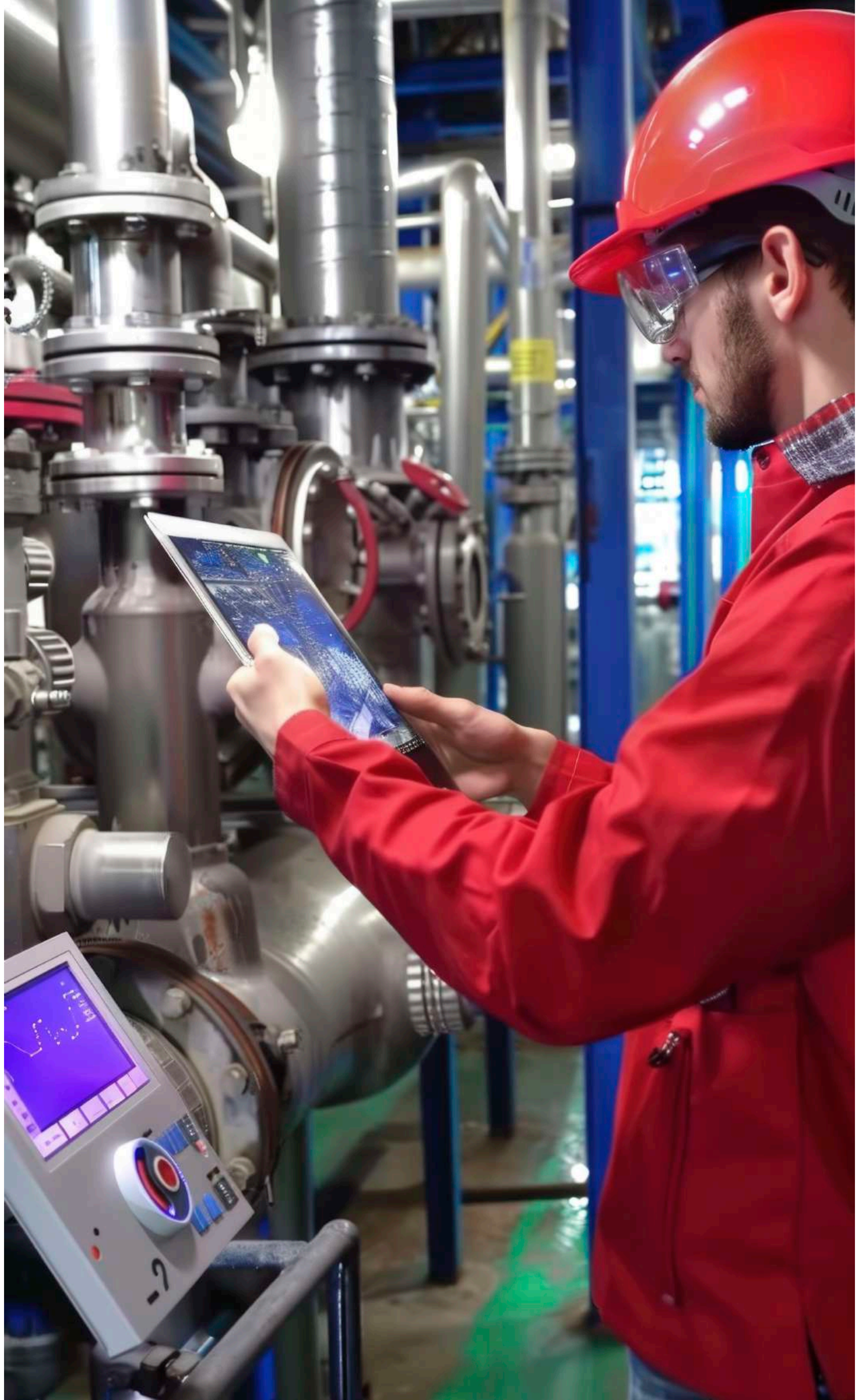
Design for High ΔT (Temperature Differential)

Aim for a larger ΔT (e.g., 8–10 K at design load) so that flow rates are lower, which reduces pipe size, friction losses, and pumping energy.

Ensure coil selections and control strategies (valves, flow control, ΔT bypass, etc.) can handle such ΔT without causing “low-ΔT syndrome” or thermal comfort issues.

Provide Local Loop Infras tructure per Zone

On each mechanical floor: distribution headers, expansion vessel, air-separators/air-vents at top of each riser, proper insulation and vapor barriers,



housekeeping pads for pumps, pressure gauges, isolation valves, balancing valves, etc.

Short risers to floor AHUs/FCUs to minimize further static head and simplify balancing.

Hydraulic Analysis, Safety & Control

Calculate worst-case static + dynamic pressures, including potential VFD failure (i.e. pump shut-off head) — as per standard practice. ASHRAE guidance explicitly states to consider shut-off head in design even if VFD is used.

Provide safety relief valves / pressure relief provisions where needed.

Provide controls (valves) to isolate zones in case of maintenance or heat-exchanger failure.

Control Logic, Sensors & PID Controls.

The pump controller shall execute the pump sequencing and modulation logic in response to system load demand. Control shall be based on continuous feedback from field-mounted sensors, including pressure, temperature, and flow devices. Sensors and flow meters shall be selected, installed, and located in accordance with good engineering practice and applicable ASHRAE guidelines to ensure accurate, reliable, and timely input signals required for stable, efficient, and energy-optimized system operation.

Beyond Drawings: How Virtual Reality is Transforming Construction Design

Prakash D & Shruthi N
Technical Director - Design Management

For decades, the construction industry has relied on two-dimensional drawings as the primary medium to communicate design intent. While these drawings remain essential contractual documents, they often fall short when projects become MEPF -intensive, structurally complex, or fast-tracked. Misinterpretation of drawings, late-stage clashes, and costly site rework continue to challenge project teams—particularly in high-rise developments, hospitals, IT parks, and data centers.

This is where Virtual Reality (VR) is redefining how construction projects are visualized, coordinated, and delivered. By moving beyond standard drawings into immersive, experience-driven environments, VR enables stakeholders to walk

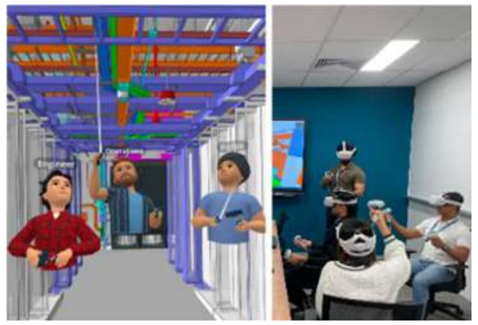
through spaces virtually, detect issues early, and make informed decisions with greater confidence.

Construction is no longer confined to paper-based representation. It is evolving into a shared, interactive ecosystem where architects, engineers, contractors, and clients collaborate seamlessly — resulting in improved clarity, reduced rework, enhanced safety, and faster project delivery. Understanding AR, VR, and MR

Before exploring VR's impact on project delivery, it is important to distinguish between the key immersive technologies used in construction today:

Augmented Reality (AR) overlays digital information onto the physical world. It is commonly used on site to verify MEP routing, equipment locations, and asbuilt conditions.

Virtual Reality (VR) creates a fully immersive digital environment in which users can experience a building before it is constructed. This makes VR particularly effective for design coordination, constructability reviews, and stakeholder engagement.



Mixed Reality (MR) blends physical and digital environments, allowing users to interact with virtual models anchored in real space.

Key Ways VR Is Transforming Construction Projects

Strengthening Project Coordination One of the most significant benefits of VR lies in multidisciplinary coordination. Architecture, structure, MEP, construction, and project management teams can review coordinated BIM models together within a shared virtual environment. This enhances alignment, reduces interface conflicts, and supports faster, more confident decision-making.

For complex scopes such as basements, excavation works, diaphragm walls, and shoring systems, VR enables clear visualization of construction stages and coordination requirements that are difficult to interpret through drawings alone.

Improving Communication with Stakeholders

VR simplifies communication with non-technical stakeholders by translating design intent into an intuitive, visual experience. Clients, Design consultants, architect, contractor and end-user can virtually experience the project, leading to quicker approvals, reduced uncertainty, and greater confidence in both design and execution strategies.

Enhancing Safety and Risk Management

Safety training is another area where VR delivers measurable value. High-risk activities and emergency scenarios can be simulated in a controlled virtual environment, allowing site teams to rehearse procedures before execution. This improves hazard awareness, strengthens preparedness, and contributes to a stronger safety culture on site.

Supporting Smarter Decision-Making

When integrated with BIM models and project schedules, VR enables teams to analyze design alternatives, construction sequencing, and logistical constraints early in the project lifecycle. This proactive approach helps minimize errors, control costs, and maintain project timelines.

Integrating VR into the Design Workflow

VR does not replace existing processes—it enhances BIM-based workflows. A practical integration approach includes:

1. Developing coordinated BIM models
2. Linking models to VR platforms
3. Conducting immersive design and coordination workshops
4. Freezing layouts earlier with higher confidence
5. Using VR outputs for client approvals and site team alignment

This structured approach significantly reduces latestage design changes and improves overall project certainty.

The Future of Project Delivery

As digital tools continue to evolve, VR is becoming an integral component of modern project delivery. When combined with BIM, scheduling, and cost

Conclusion: The Future Is Beyond Drawings

The future of construction design does not lie in eliminating drawings, but in augmenting them with immersive technologies. Virtual Reality takes project teams beyond drawings and traditional models into environments where ideas, designs, and execution strategies can be experienced before they are built. management systems, VR enables a shift from reactive problem-solving to predictive, collaborative project management.

By improving coordination, communication, and risk management, VR is not merely enhancing visualization—it is redefining how successful projects are delivered.

Beyond drawings is not a trend; it is the next evolution of construction design.

Sports and Wellness


DesignTree Cricket Premier League 2026










DesignTree Badminton Tournament 2026

Kannada Rajyotsava







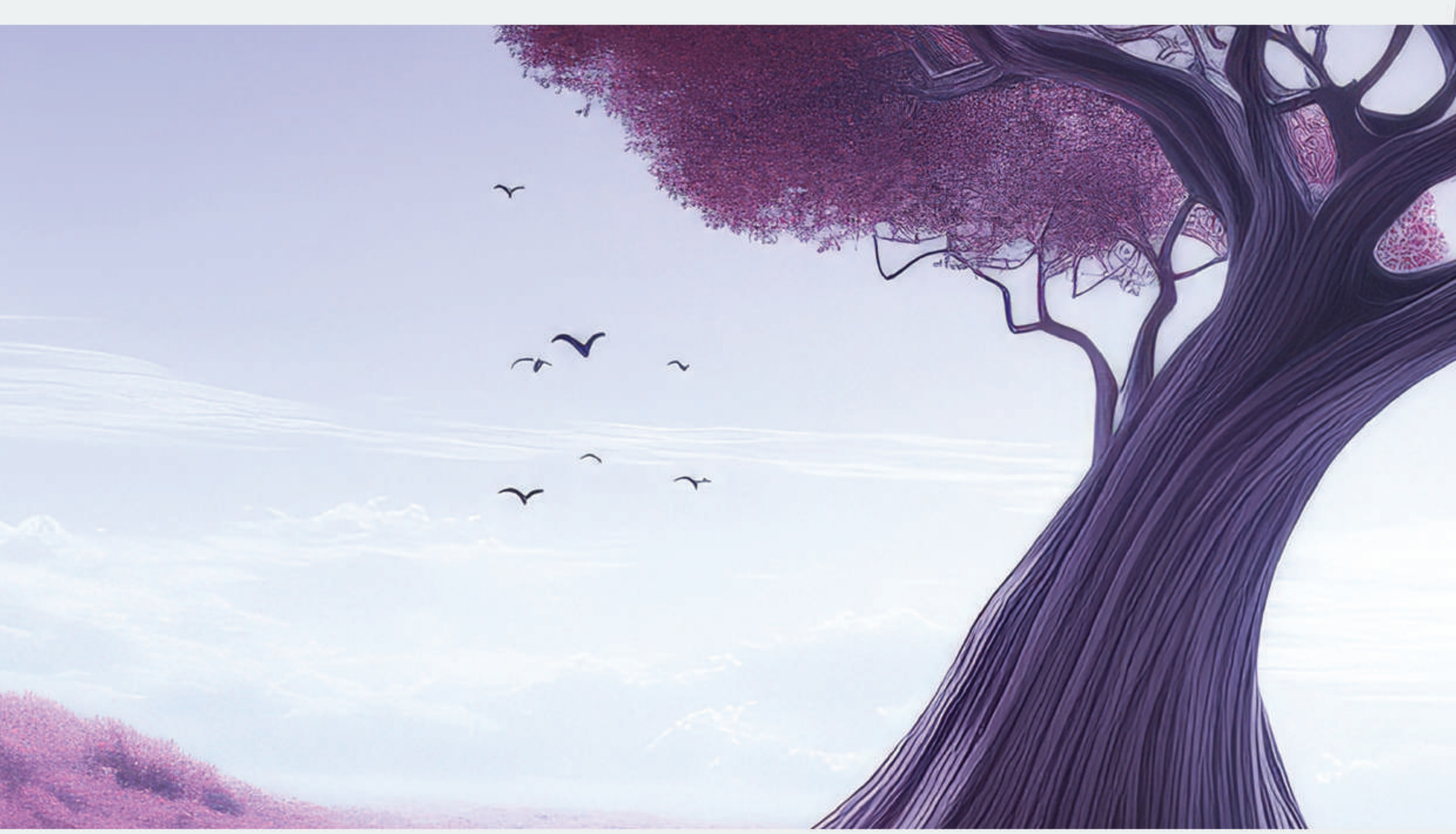




CSR Activities

Civil | Structures | Public Health | Fire Protection | Electrical | HVAC | Green Building | Infrastructure

BANGALORE | CHENNAI | HYDERABAD | KOLKATA | MUMBAI | PUNE | VIJAYAWADA



Scan for website
https://www.designtreeconsultants.com/