

Conveyance Systems in Data Centers & Structural Design Considerations

Presented by Joel Fairfax, PE, SE





Introduction

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HDR's Design Experience

1917

Year Established

100+

Design Awards

225+

Global Offices

40+

Years of Experience in
the Data Center Space

13,500+

Architects, Engineers,
and Planning Staff

10+ million SF

of Data Center Experience
over the past 40 Years

BD+C Giants, 2023, 2024

No. 2 Top Architecture/Engineering Firms

No. 2 Top Data Centers A/AE Firms

Building Design, World Architecture 100 Survey, 2024

No. 1 Science & Technology A/AE Firms

No. 2 Design Firms in North America

No. 3 Top 100 Global Architecture Practices

By Service

No. 2 – Architecture

No. 2 – Interior Design

No. 3 – Engineering

No. 3 – Consulting

No. 3 – Urban Design

No. 5 – Project Management

ENR, 2024

No. 2 Top R&D Building Design Firms

No. 6 Top 100 Architecture Firms

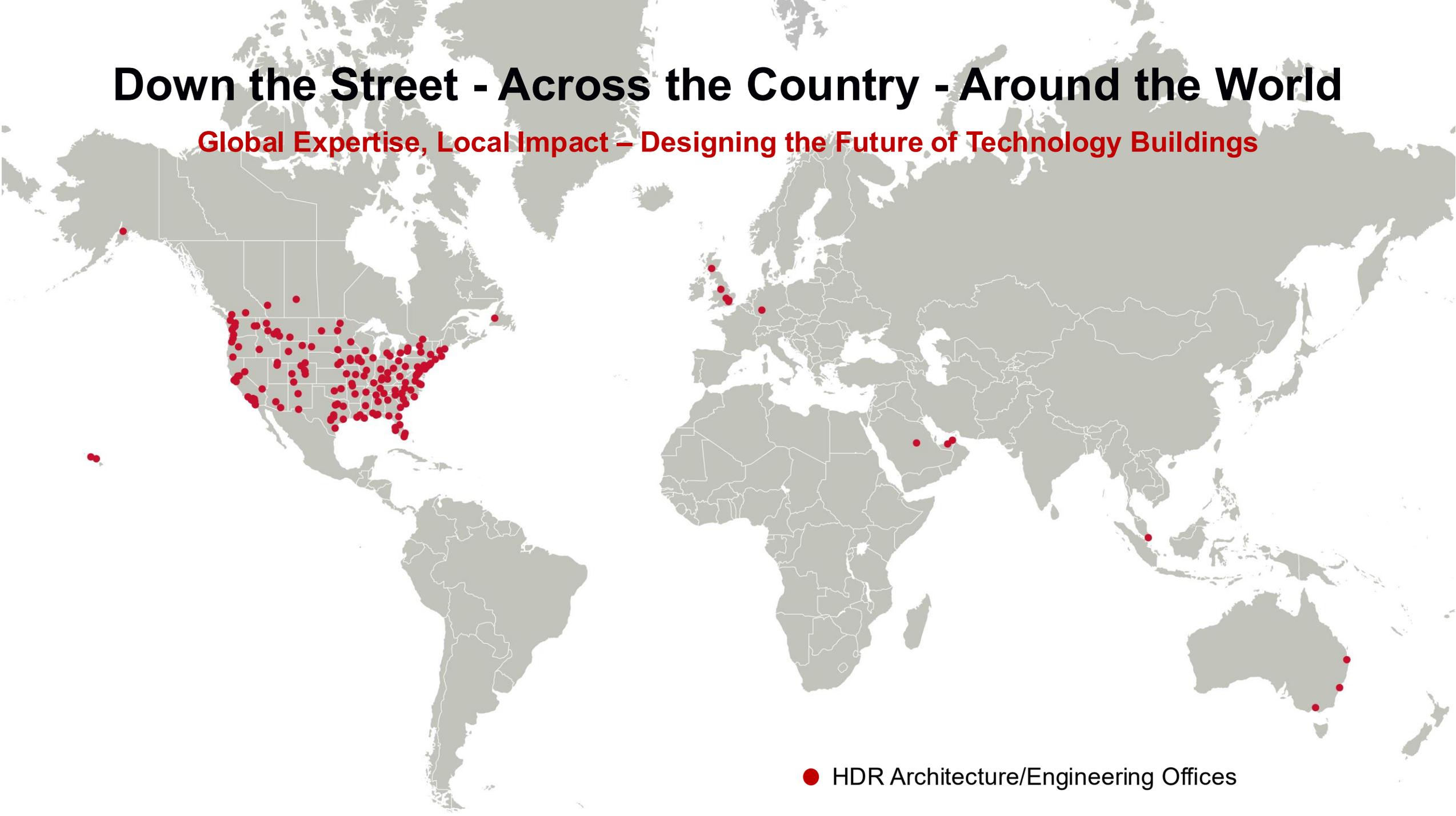
No. 4 Top 25 in Wastewater Treatment

No. 9 Top 100 in Green Buildings Design Firms

No. 12 Top 20 in Power Design Firms

Down the Street - Across the Country - Around the World

Global Expertise, Local Impact – Designing the Future of Technology Buildings



● HDR Architecture/Engineering Offices

Disclaimer



- Highly competitive field our clients operate within
- Proprietary systems and equipment are constantly developed
- Due to this, this presentation will stay generic in nature

Data Center Market Segments & Design Drivers

Hyperscale Cloud



- 300 acres and up sites
- 50 MW – 500+ MW Facilities
- Mixture of Air/Water cooled systems

Co-Location



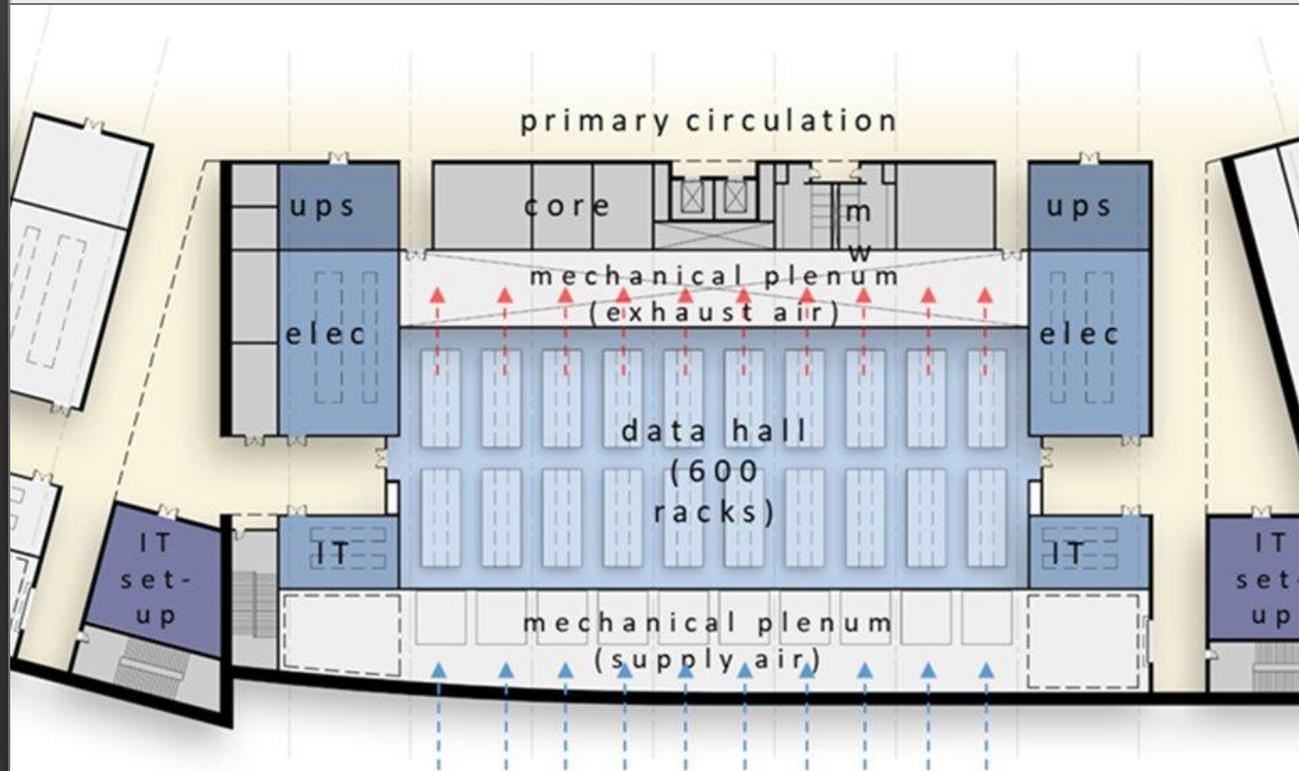
- 30 Acres plus sites
- 10 MW – 80 MW Facilities
- Air Cooled predominantly

AI



- Adaptable to most sites
- Power availability is key
- Significantly more density and likely more robust MEP systems (water to chip)

Airflow Driven Architecture

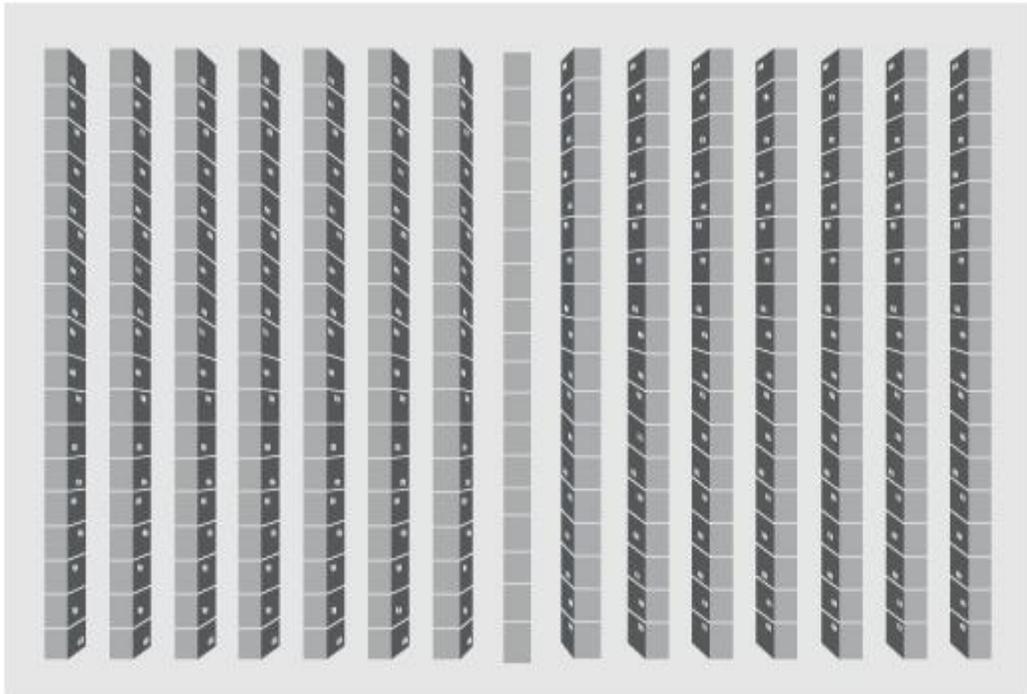


Air Cooled Data Center

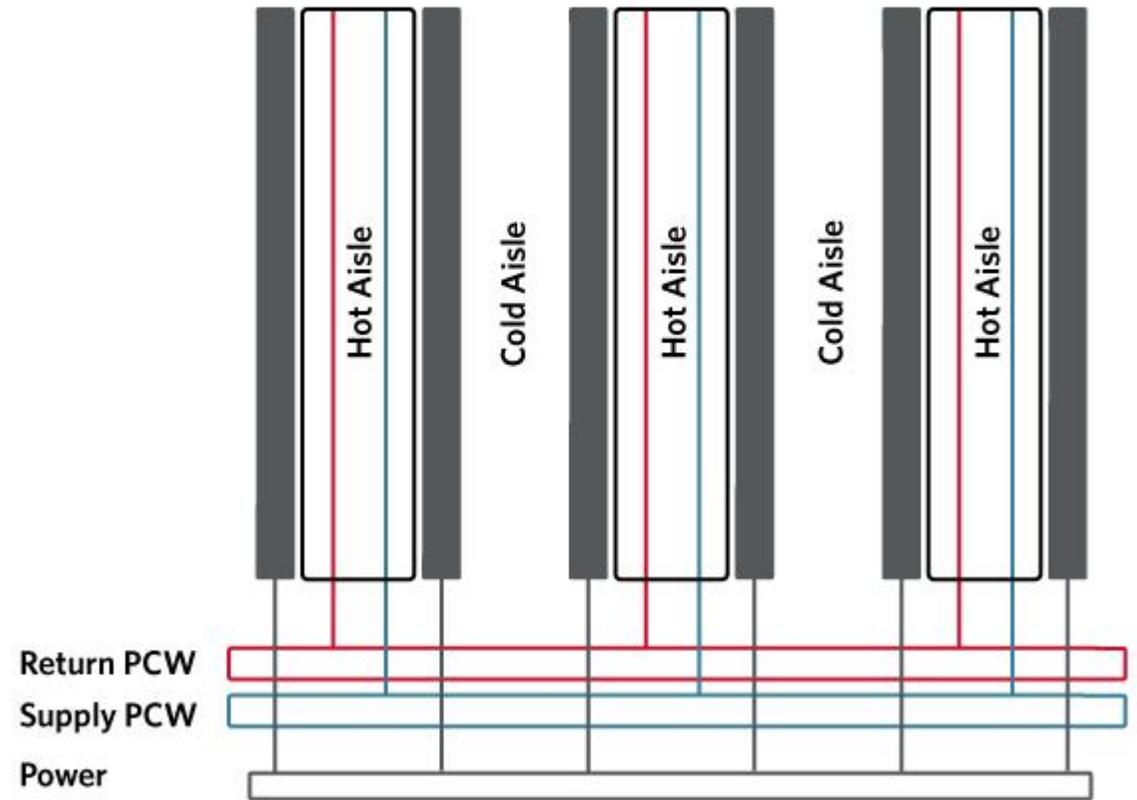
- **Relationship Between Space, Power & Cooling**
 - 10kW – 30kW per Cabinet
 - 40 – 50 MW Data Centers
- **Approximate Space Planning Ratios:**
 - 40% Data Hall
 - 40% MEP
 - 20% Support

Data Center Site Layout

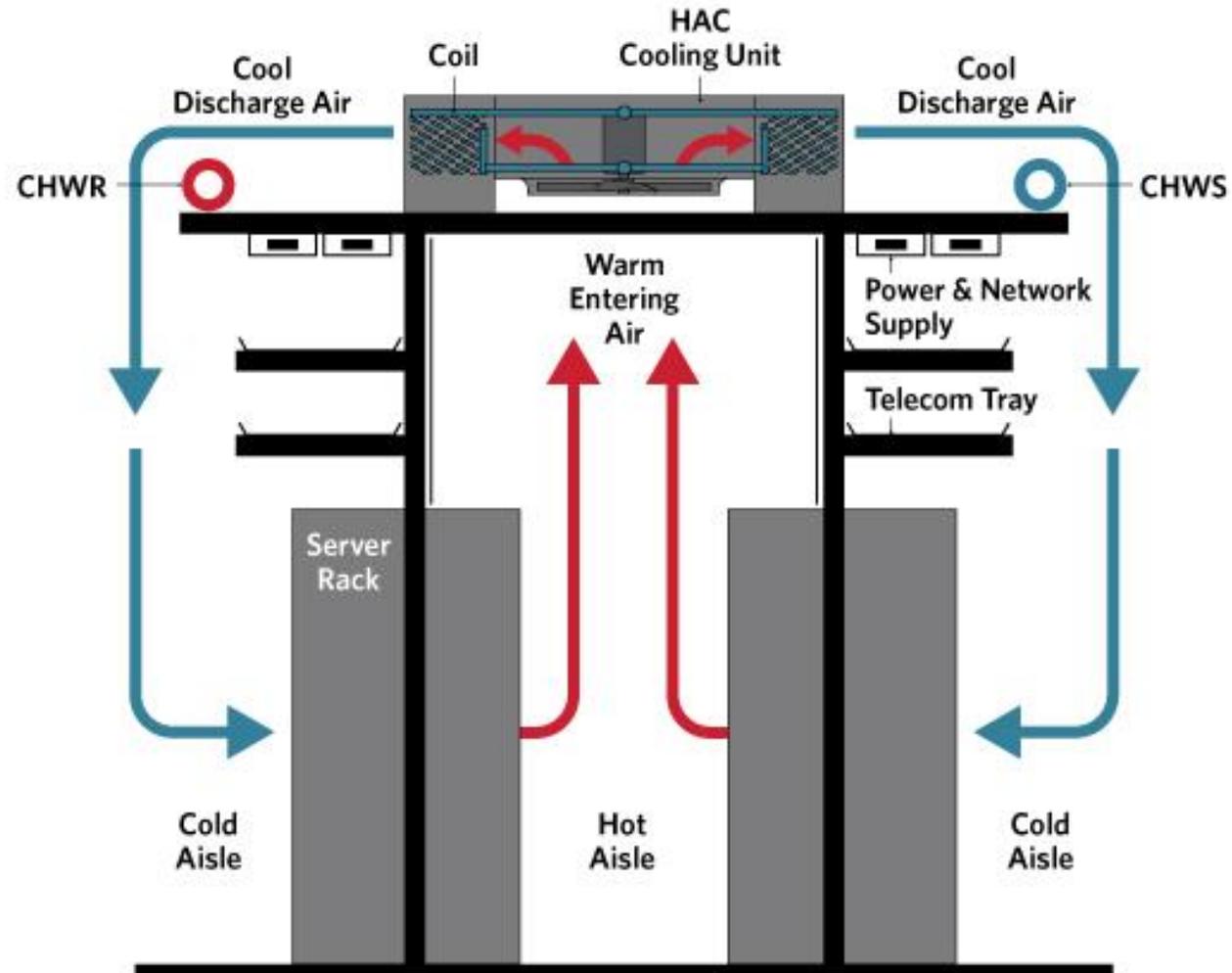
Data Hall Layout



Server Rack Connections



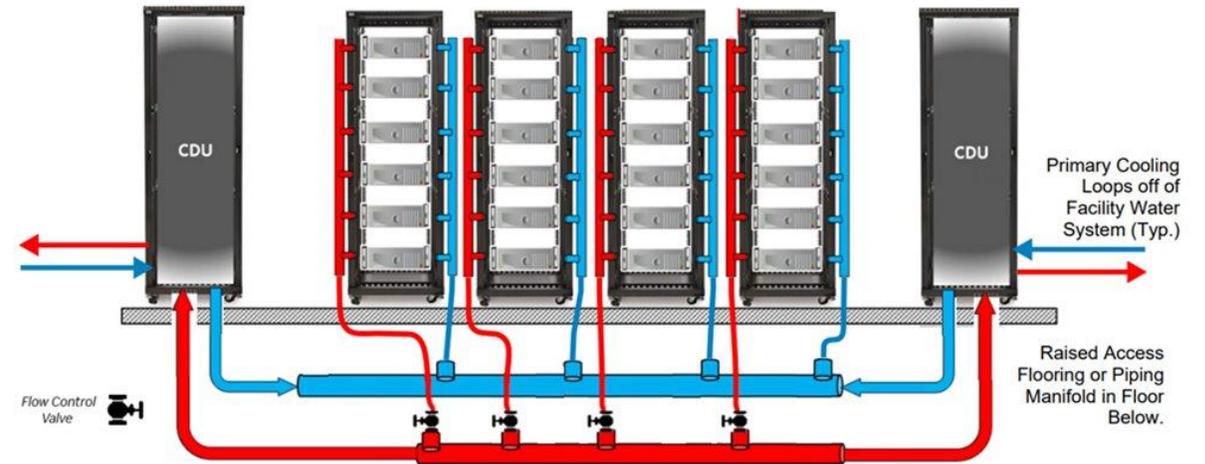
Server Rack Configuration



AI Liquid Cooled Data Center

AI Direct to Chip Cooling:

- Thermal Storage / Buffer Tanks
- Under Floor | Overhead
- Less data hall space, more electrical



AI Data Center Power

AI workloads & training models require more energy than traditional loads

- AI tasks cause rapid, high-frequency power fluctuations
- Idle & Low Load <40%
- High Intensity Load >90%
- Overload Peaks up to 120%
- Use of large scale batteries used to soften the power demand spikes on equipment



Systems Overview

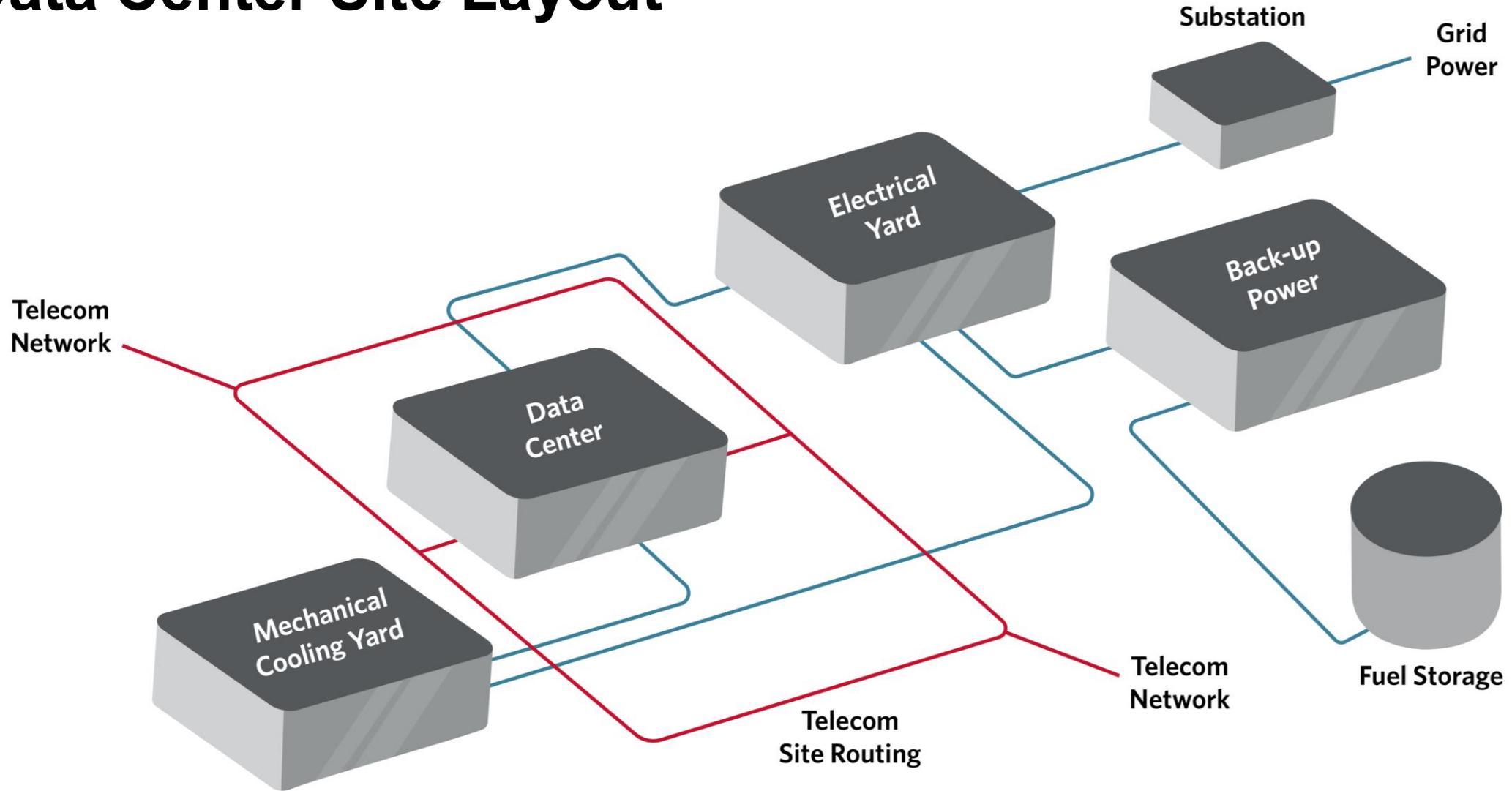
Data centers house critical IT infrastructure requiring continuous power, precise cooling, and high-speed connectivity

For Hyperscale Data Centers, the power distribution and cooling facilities are often located in consolidated areas away from the server halls

Systems conveyed across Data Center sites:

- Processed Chilled Water
- Electrical Power
- Telecommunications Fiber
- Fuel Distribution Systems

Data Center Site Layout



Process Chilled Water Piping Systems

Two common cooling system types:
Evaporative & Non-Evaporative



Function: Removing heat from servers and networking gear



Components: Includes chillers, cooling towers, pumps, heat exchangers and insulated piping



Materials: carbon steel, stainless steel, or specialized plastics (HDPE)



The Challenge: Significant thermal loads. Pipes contract and expand due to temperature differentials (Supply: 65–75°F; Return: 95–105°F)

Piping can vary in size from 6-12" for branch piping at equipment and header mains can be 24" and up

Process Chilled Water Piping Systems

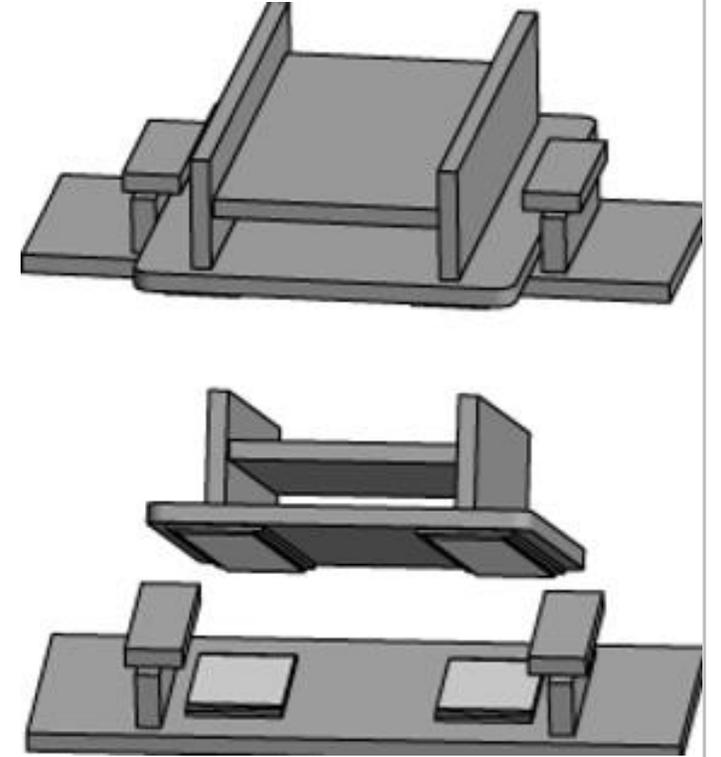
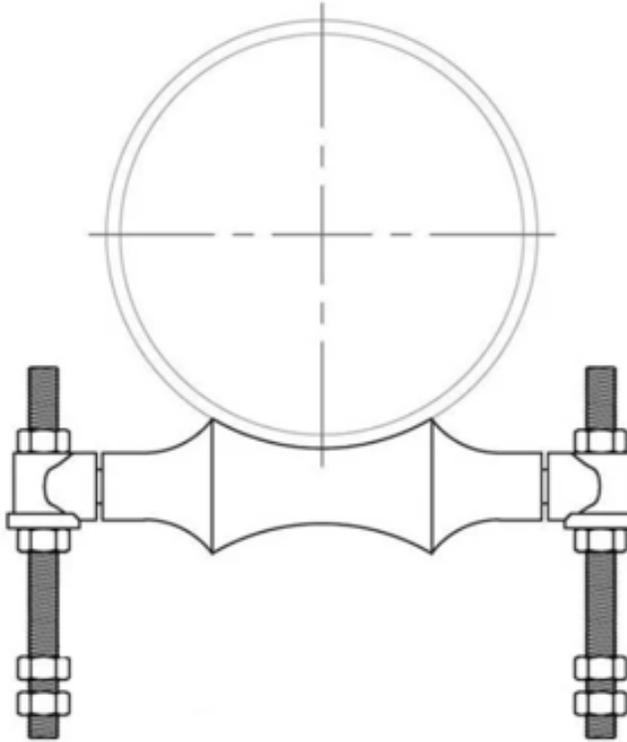
Working with a pipe stress engineer is critical

- Coordination on loading criteria
- Support type and location coordination
- Location of anchor points
- Reactions from piping to support system
- Long runs of piping can generate multiple inches of thermal movement
- **Large pipes can be stiffer than the support structure**
 - Look at differential deflections to ensure support structure does not sag lower than piping system and redistribute pipe reactions

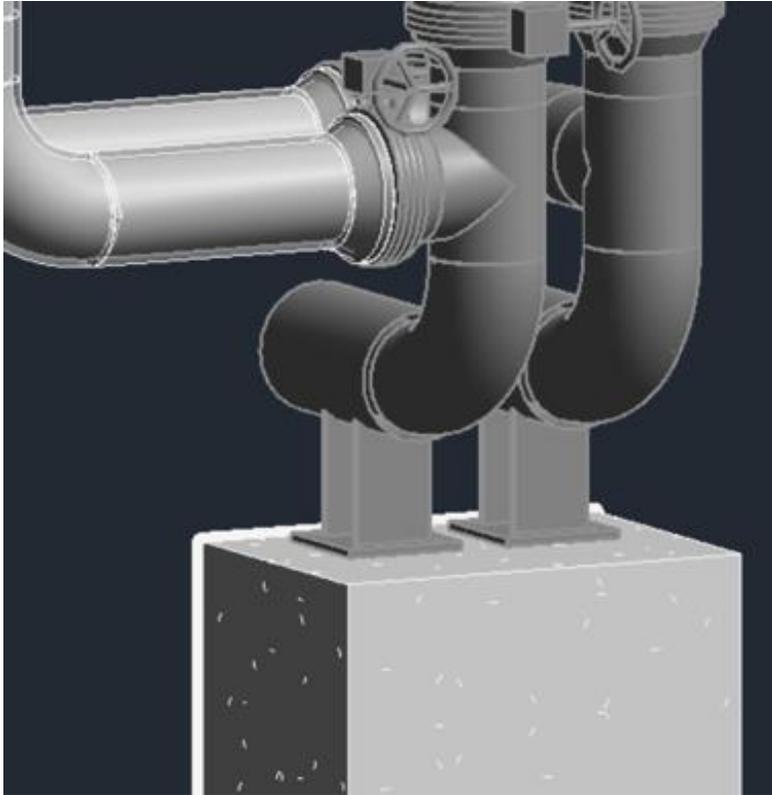
Managing Pipe Thermal Movement

Pipe Guides

Restraints that allow axial movement but prevent lateral displacement



Managing Pipe Thermal Movement

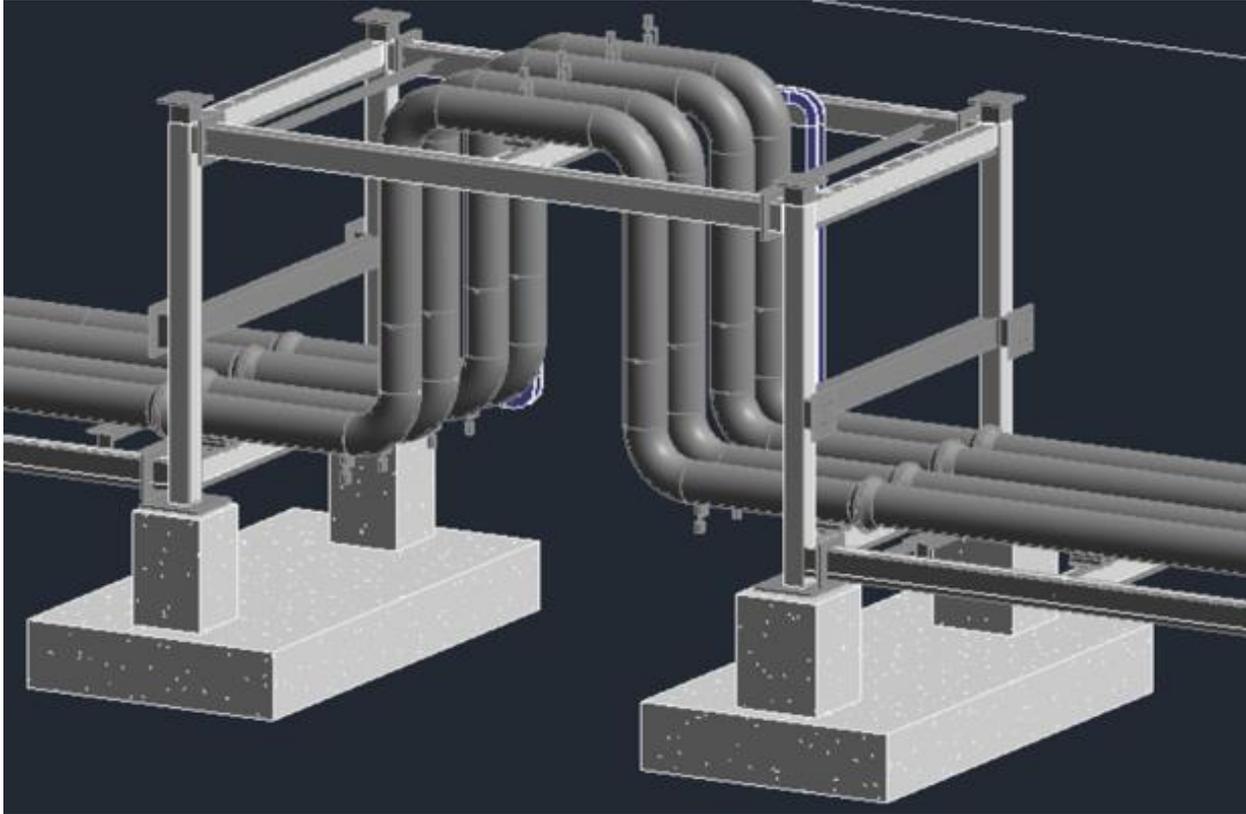


Anchors

Strategically placed to lock in pipe points and direct movement toward expansion devices

- Pipe Anchors are designed to restrict lateral and often rotational movement
- Best if located directly on foundation, if elevated on structure, PSA needs to factor in structure flexibility

Managing Pipe Thermal Movement



Expansion Loops

Purpose-built loops to provide flexibility points

Electrical Power Conveyance

Delivers conditioned power from the utility grid to IT equipment

Key Infrastructure



Utility Infeed, Switchgear and Transformers



Busbar Systems: Modular, prefabricated distribution for scalability



Generators and UPS systems



Conduit & Cable Trays: Protect and organize dense cable bundles



PDUs/RPPs: Distribute power to individual racks for redundancy



Considerations for Electrical Systems

Clearance: Adequate spacing between power and data cables is required to prevent Electromagnetic Interference

Flexibility: Cable tray and conduit can be considered flexible and easily starts and stop at structure transitions. Cable bus and busway are rigid

Supports must ensure proper grounding and bonding

Telecommunications Fiber Conveyance



Carries data at high speeds

Lightweight but fragile; requires protection from compression and tight bends

In ground is the common conveyance method

- Connecting precast fiber vaults via in ground conduit routes within concrete encasements
- Provides most durable and protected system
- **Innerduct:** flexible conduits contained within larger conduits
 - Provides additional layer of protection from ground movement/settlement

Fuel Distribution Systems



Used at backup generator yards

- Centralized storage tank with a distribution pipe network to individual generators
- Belly tanks at each generator fed by central fill and pump station

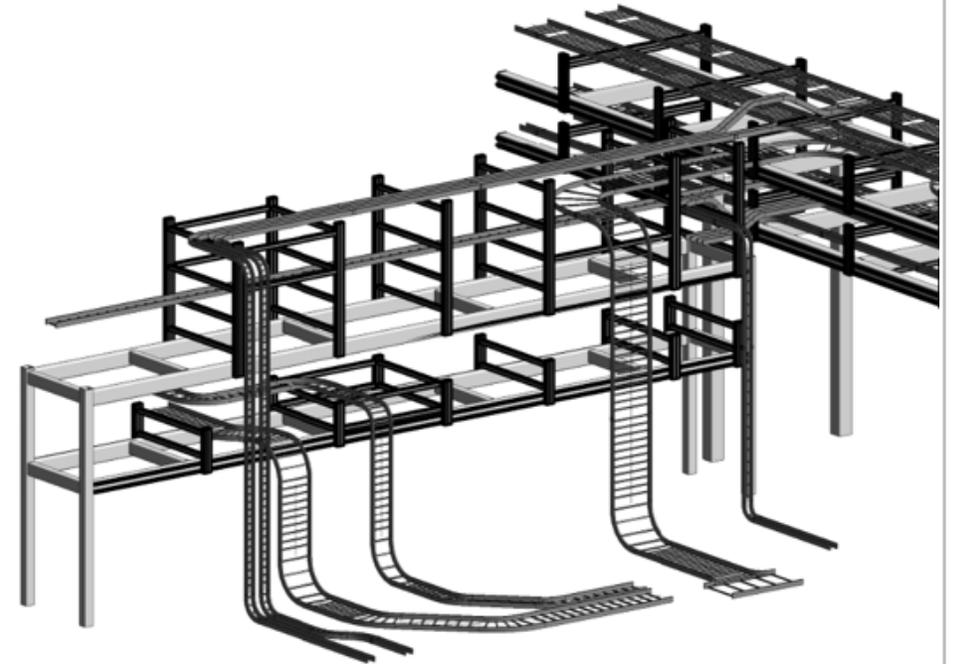


Conveyance Routing Options

- Above Grade Trestles
- In-Ground Open Trench
- Buried

Above Grade Trestle

- Open access eases installation and maintenance
- Steel design allows for many options of suppliers reducing risk of supply chain bottlenecks
- Off site pre-assembly can increase construction speed
- **Road crossings trestles are often required**
 - 18' clear heights required if fire access route
- **Routing lengths can be on the order of 1000's of feet**
 - Thermal movement of support steel and supported elements needs to be considered
 - Differential movement between structures



Above Grade Trestle

Design Criteria



Snow & Ice



Wind



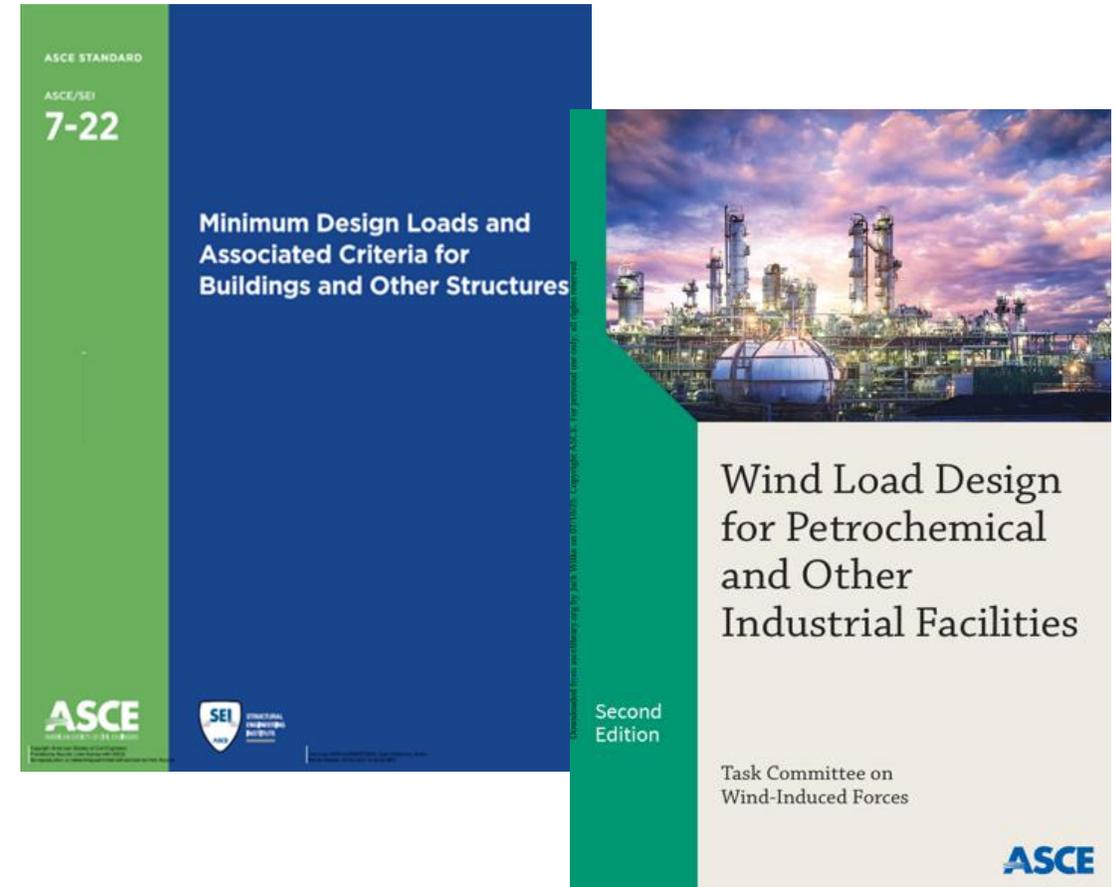
Seismic



Thermal Growth

- ASHREA Fundamentals
- NOAA / National Weather Service
- AASHTO LRFD Bridge Design

Design Standards

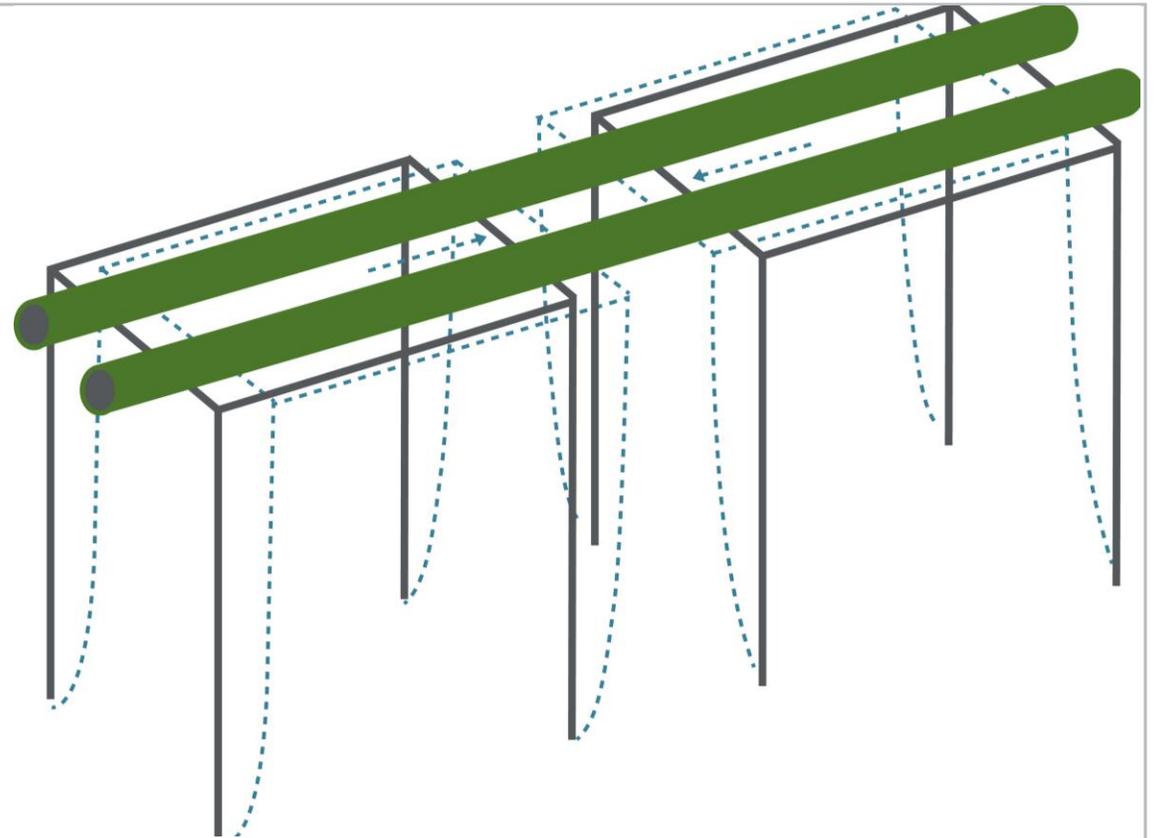


Managing Differential Movement

Continuous systems often cross independent structures with different settlement patterns or seismic responses

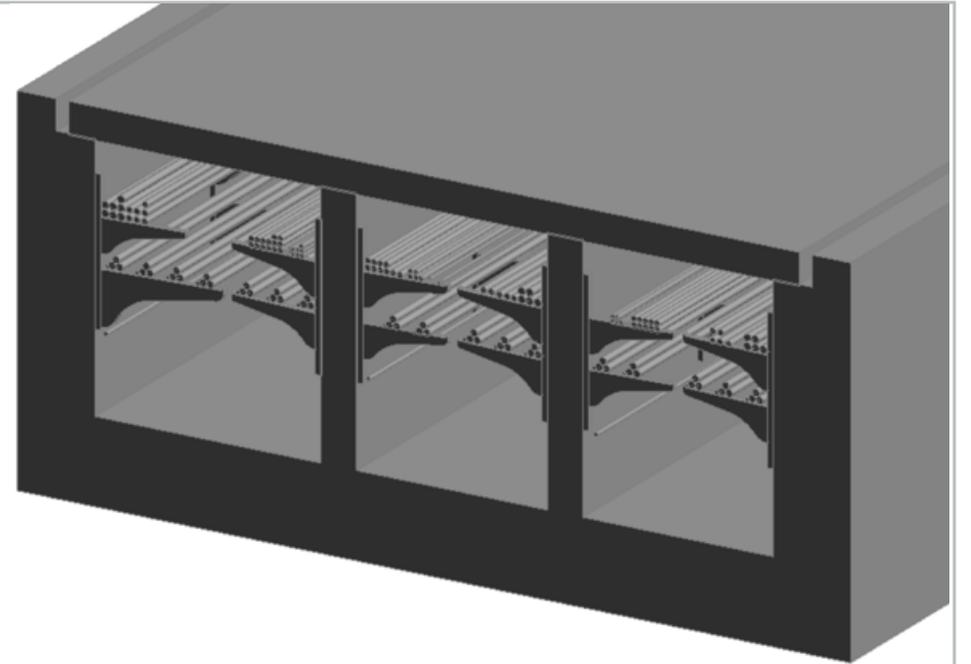
Strategies

- **Flexible Connections:** Bellows or hose connections at structure transitions
- **Slip/Roller Supports:** Allow axial movement for heavy trays or busducts
- **Seismic Gaps:** Specialized bracing and couplings to permit large displacements during earthquakes



In-Ground Trenches

- **Precast or Cast in Place Options**
- Opens site access as conveyance is moved underground out of maintenance routes
- Open grating often required for access and heat dissipation
- Aesthetically more pleasing than a congested above ground conveyance system
- Potentially more time-consuming construction
 - Weather delays with large open excavations are a risk
- Expansive soils can be problematic
- Drainage of open trenches requires coordination with civil storm system





Buried

- **Most protected conveyance path**
- Used if maintenance is expected to be minimal or not required
- Buried power cables needs to be de-rated due to heat build up
- Boring PCW piping is time consuming and avoiding clashes with underground utilities can be a challenge
- Expansive soils can be problematic

Speed to Market & Prefabrication

Rapid digital growth demands compressed construction schedules

Prefabrication Benefits

- **Modular Racks:** Pre-assembled steel segments with piping and trays
- **Skid-Mounted Systems:** Pumps/switchgear built off-site as single units
- **Advantages:** Reduced on-site labor, improved quality control and enhanced safety
- **Proprietary Framing:** Systems like Unistrut or Hilti allow bolt-together assembly without welding



Conclusion

- Successful data center design balances complexity with resilience
- Integrated coordination between engineering disciplines is essential for managing thermal movement, structural loads, and underground conflicts
- Innovative construction through prefabrication is the key to meeting modern "speed to market" demands



Questions

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HDR