SECTION 2

PT SYSTEMS

DEVELOPED BY THE PTI EDC-130 EDUCATION COMMITTEE

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OUTLINE

- Unbonded and Bonded Post-Tensioning Comparison
- Unbonded Post-Tensioning:
  - Systems and equipment
  - Function of the coated tendon
  - Construction
- Bonded Post-Tensioning:
  - Various systems, components and equipment
  - Function of the grouted tendon
  - Construction
- Post-Tensioning Applications

UNBONDED AND BONDED PT COMPARISON

- Unbonded Post-Tensioning (PT)
  - Tendon is not bonded to the surrounding concrete
  - PT force is transmitted to the structure by means of the anchorages.
- Bonded Post-Tensioning (PT)
  - Tendon is bonded to the concrete
  - Bond is achieved throughout the length of the tendon by a cementitious matrix called grout.
  - Bond between the strand and the concrete is achieved through the duct after grouting
  - PT force at every section is a function of the deformation of the concrete (strain compatibility)

UNBONDED AND BONDED PT COMPARISON

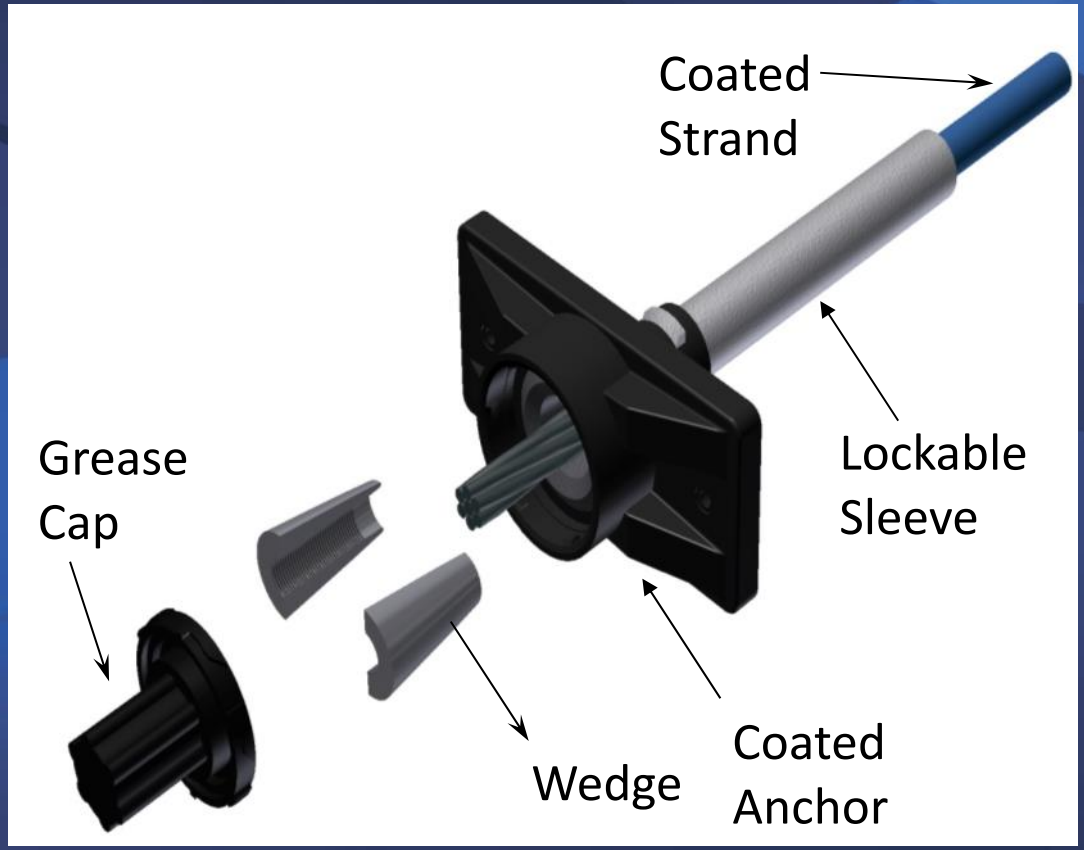
- Applications: both systems are used in building and civil structures (bridges, containment structures, etc…)
  - In USA, unbonded is more common in buildings
  - Bonded is more common in civil structures
  - Both systems can be used as external post-tensioning
- Performance and durability: both systems provide comparable satisfactory results
- Selection of a system depends on:
  - Availability
  - Economics
  - Specific needs of each project

MAJOR CONSTRUCTABILITY DIFFERENCES

	Unbonded	Bonded
Fabrication of tendons in plant (extrusion & cutting to specific length)	Necessary	Not necessary but possible
Placement	Very practical and flexible. Easy to handle and does not necessitate heavy equipment	Very practical and flexible. Depending on application and system used, may require heavy equipment and reduced flexibility
Grouting	Not Applicable	Necessary
Stressing	Single strand stressing	Typically multi-strands with high stressing forces. Single strand stressing in specifc systems
Demolition	Requires special care	Straight forward (similar to regular reinforcement)

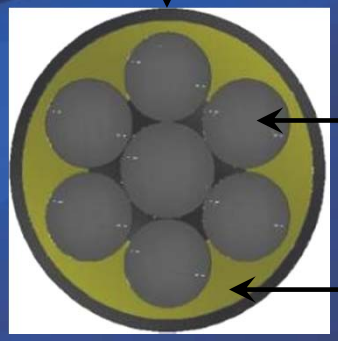
UNBONDED SYSTEMS

- Monostrand PT systems:
  - Coated strand
  - Coated anchors
  - Encapsulation accessories
  - Wedges



UNBONDED PT COATED STRAND

- The process of coating the strand is called extrusion
- Coated strand
  - 7-wire PC strand: ultimate strength f_{pu}= 270 ksi
  - Plastic sheathing: High Density Polyethylene (HDPE) or Polypropylene (PP)
  - PT coating: Corrosion inhibiting grease



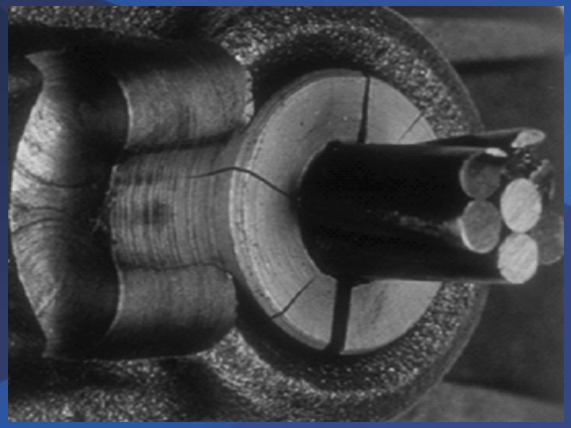
Tendon Section

UNBONDED PT ANCHORAGE

- Encapsulated anchorage
  - Prevent water infiltration and corrosion
  - Monostrand steel anchor coated with corrosion protection
  - Lockable encapsulation sleeves
  - Encapsulation cap to cover strand tails (ends)
  - Plastic pocket former

STEEL WEDGE

- Wedges are responsible of locking the strand after stressing so it holds the force
- Wedges are made of steel and have ductile core to adjust to strand shapes



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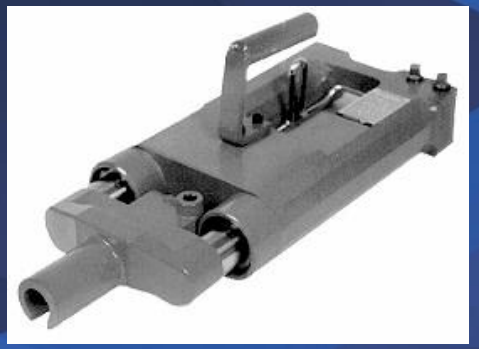
FUNCTION OF STRAND COATING

- Function of the PT coating
  - Allow a bond free movement of the strand inside the sheathing.
  - Increase protection against corrosion and provide a non-conductive environment for corrosion
  - Reduce friction between the strand and sheathing
- Function of the sheathing
  - Provide corrosion protection to the strand
  - Provide encasement against damage and moisture penetration

UNBONDED PT STRESSING EQUIPMENT



Monostrand Stressing Jack

Stressing Pump

Gauge

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UNBONDED PT CONSTRUCTION

- Tendon fabrication (PTI certified plants)
- Site installation
- Inspection and concrete placement
- Stressing operation

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UNBONDED PT FABRICATION

- Tendon extrusion and cutting to length
- Tendon bundling
- Tendon color coding & labeling
- Loading and shipping to site

PROJECT DATA	
NAME	:
LEVEL	: Fifth Floor
POUR #	: P16-Slab
DRAWING REF	: PT-2.06

PT TENDON DATA	
Designation	: P16-09 to P16-29
Quantity	: 42
Drawing Length	: 99 ft
Cutting Length	: 100.5 ft
Color Code	: Brown Green
Tendon Type	:
# of Intermediate	: N/A

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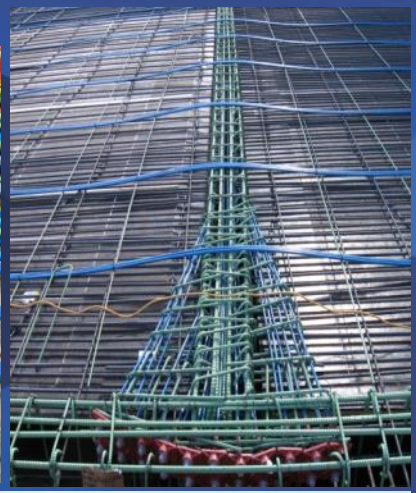
UNBONDED PT INSTALLATION

- Placing of formwork
- Fixing of anchors to side formwork
- Installing chairs to profile heights shown on PT drawings
- Installing reinforcement and PT tendons



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UNBONDED INSPECTION AND CONCRETE CASTING

- Inspect reinforcement and PT installation according to drawings
- Cast concrete
  - Thorough vibration around anchorages
  - Avoid damaging PT tendons
  - Proper curing

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UNBONDED PT STRESSING

- Remove edge formwork
- Prepare tendons for stressing
- Check achieved concrete strength
- Stress tendons using calibrated monostrand equipment
- Fill out elongation records
- Approve elongations
- Seal tendons and patch pockets

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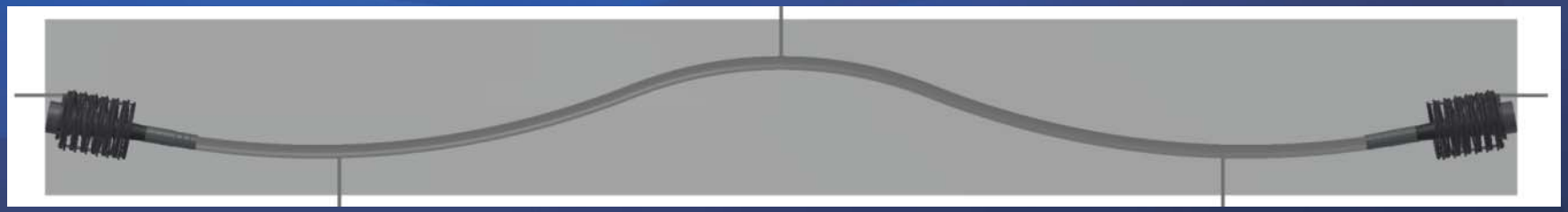
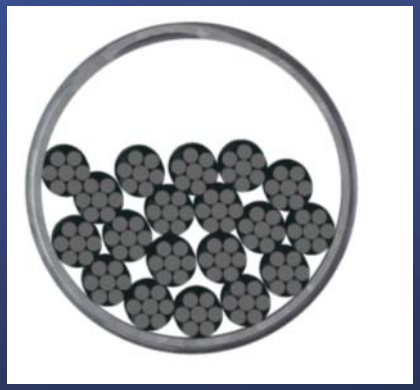
BONDED PT SYSTEMS

- Several systems exist with main components being:
  - Bare Strands or Bars
  - Steel Anchorage Assemblies (bearing plates and wedge plates); proprietary designs
  - Plastic or Galvanized Metal Ducts
  - Steel Wedges
- Typically multistrands encased in grouted duct
- Bonded systems also known as grouted systems



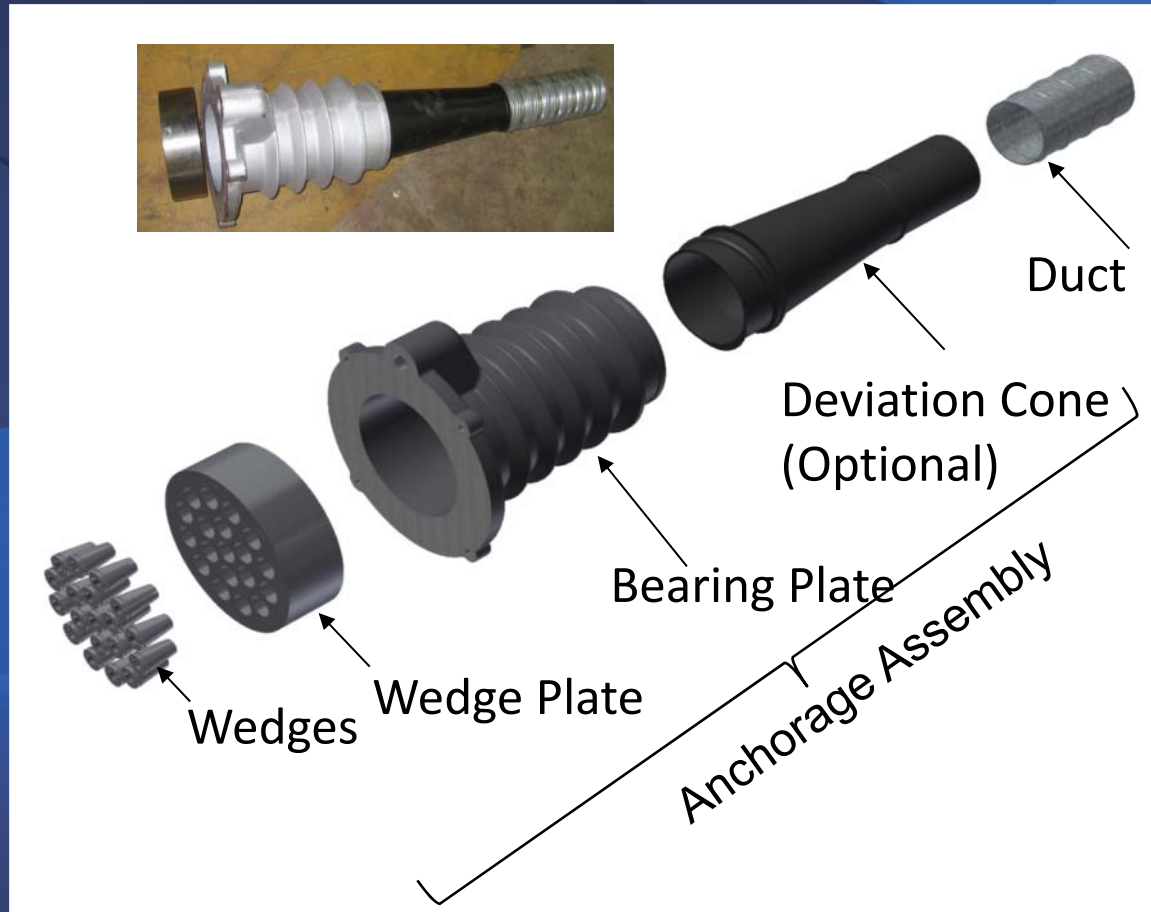
FUNCTION OF GROUTED DUCTS

- Function of the duct
  - Maintain a voided path for strands during construction
  - Transfer the bond between the grout & the concrete
  - Act as additional corrosion protection against penetration of moisture and chemicals
- Function of the grout
  - Provide a continuous bond between the strand and the duct
  - Increase protection against corrosion
  - Provide a non-conductive environment for corrosion



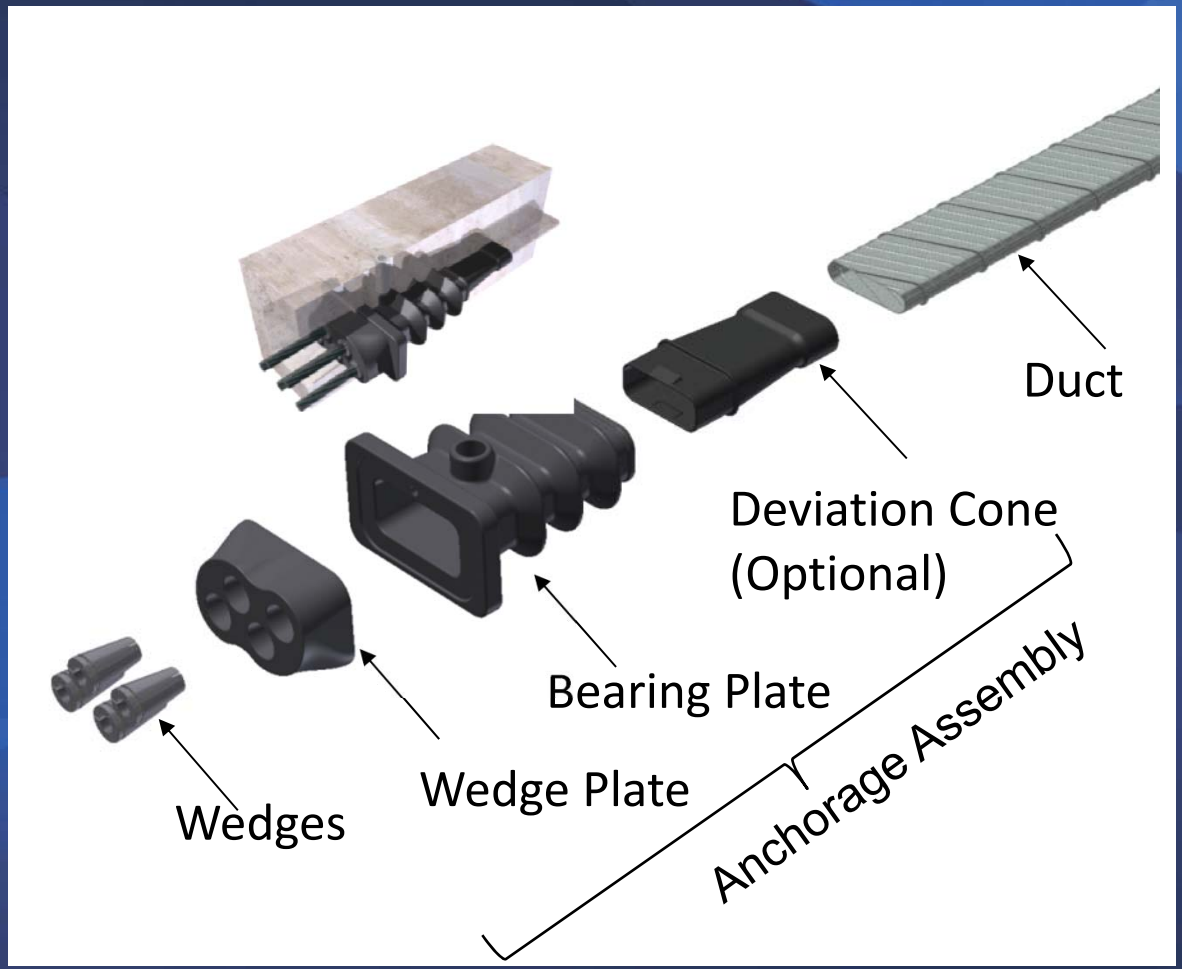
BONDED PT SYSTEMS

- High capacity multistrand systems used in civil structures and transfer beams or slab construction
- Main components
  - Bare strands
  - Multistrand anchorage assembly
  - Round corrugated duct
  - Grout accessories (cap, shut-off valves vents, etc…)
  - Wedges



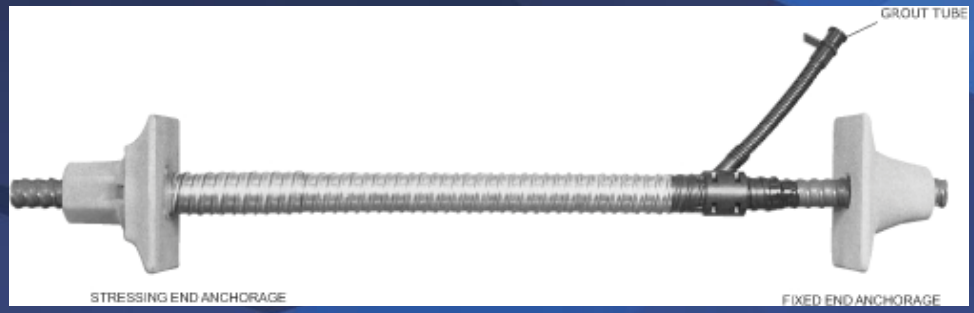
BONDED PT SYSTEMS

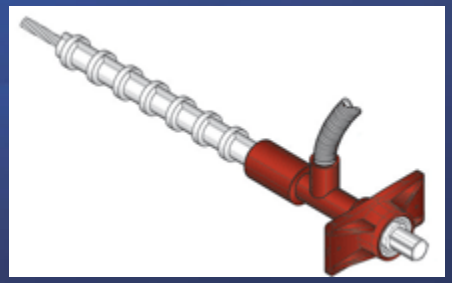
- Flat systems used typically in thin concrete elements and slab construction
- Main components
  - Bare strands
  - Multistrand anchorage assembly
  - Flat corrugated duct
  - Grout accessories (cap, vent tubes, etc.)
  - Wedges



BONDED PT SYSTEMS

- Bar systems:
  - PT bar
  - Steel anchor
  - Duct
  - Grout accessories
- Monostrand grouted system
  - Single strand anchor
  - Round duct
  - Wedge
  - Grout accessories





BONDED PT STRESSING EQUIPMENT

Stressing Jack

Strand Pusher

Stressing Pump

Grouting Machine

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BONDED PT CONSTRUCTION

- Installation
- Inspection and concrete placement
- Stressing operation
- Grouting operation

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BONDED PT SYSTEMS INSTALLATION

- Placing of formwork and side shutter
- Fixing of bearing plates
- Placing of ducts and reinforcement
- Profiling ducts according to drape specified on PT installation drawings
- Placement of strands inside duct (can be done before or after casting of concrete)

Beam/Bridge Construction

Slab Construction

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INSPECTION AND CONCRETE PLACEMENT

- Inspect reinforcement and PT installation according to placement drawings
- Cast concrete
  - Thorough vibration around bearing plates
  - Avoid damaging PT tendons
  - Proper curing

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BONDED PT SYSTEMS STRESSING

- Remove edge formwork
- Prepare tendons for stressing
- Check achieved concrete strength
- Stress tendons using calibrated equipment
- Fill up elongation records
- Approve elongations

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BONDED PT SYSTEMS GROUTING

- Check ducts for blockage
- Grout and seal tendons
- Record grouting results
- Check vents for grout adequacy




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PT APPLICATIONS:
2-WAY SLABS

Photo Courtesy of Seneca Structural Engineering Inc.

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PT APPLICATIONS: TWO-WAY SLABS

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PT APPLICATIONS: SLABS-ON-GROUND

Ribbed Foundation

PT APPLICATIONS: SLABS-ON-GROUND

Uniform Thickness Foundation

PT APPLICATIONS: MAT FOUNDATIONS

PT APPLICATIONS: INDUSTRIAL FLOORS

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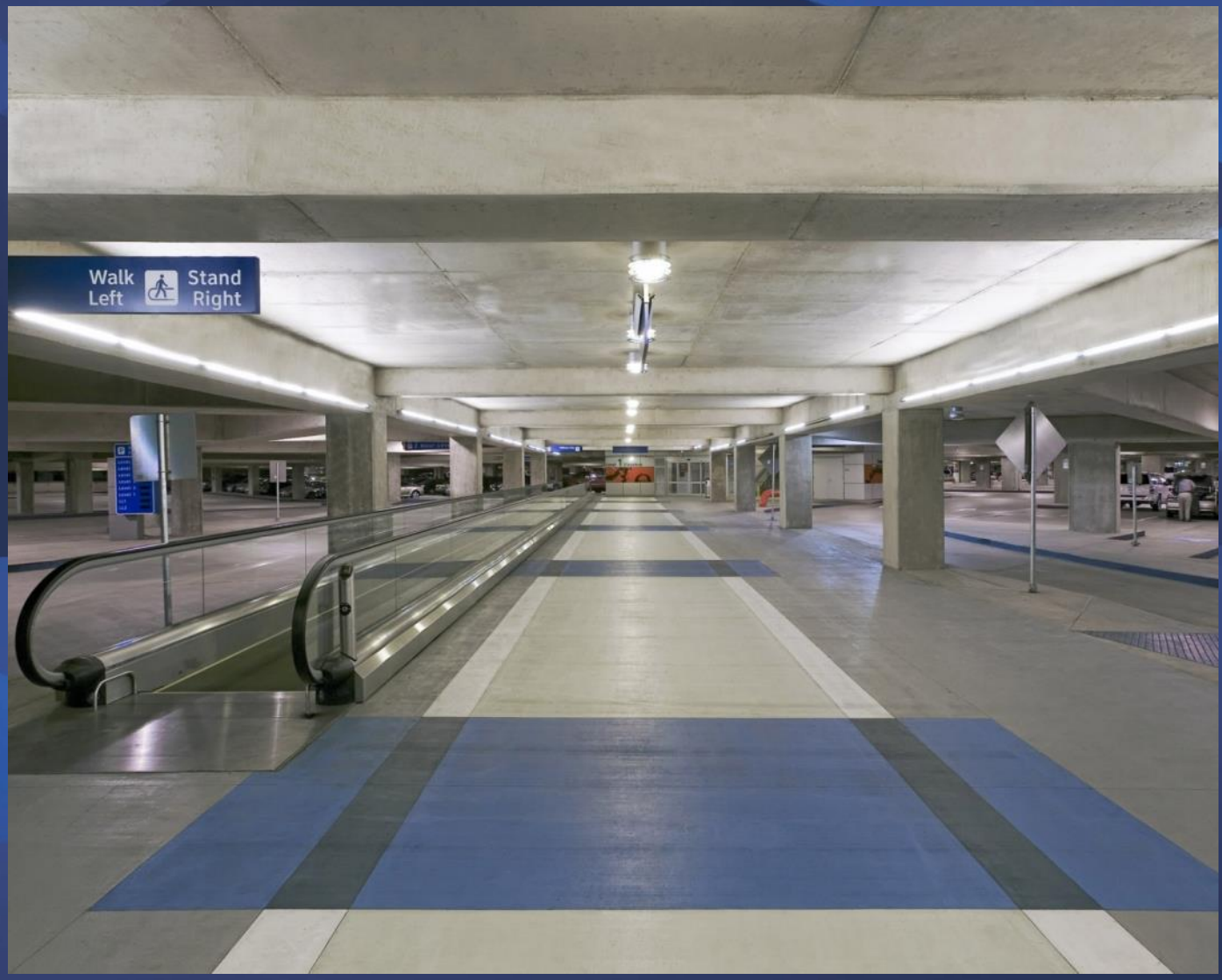
PT APPLICATIONS: PARKING STRUCTURES



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PT APPLICATIONS: GROUND ANCHORS

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PT APPLICATIONS: STORAGE STRUCTURES

PT APPLICATIONS: BARRIER CABLE

PT APPLICATIONS: STRENGTHENING

Photo courtesy of Seneca Structural Engineering

PT APPLICATIONS: STRENGTHENING

PT APPLICATIONS: SPLICED GIRDERS

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