Driven Pile Types

PDCA 2015 Professor Driven Pile Institute

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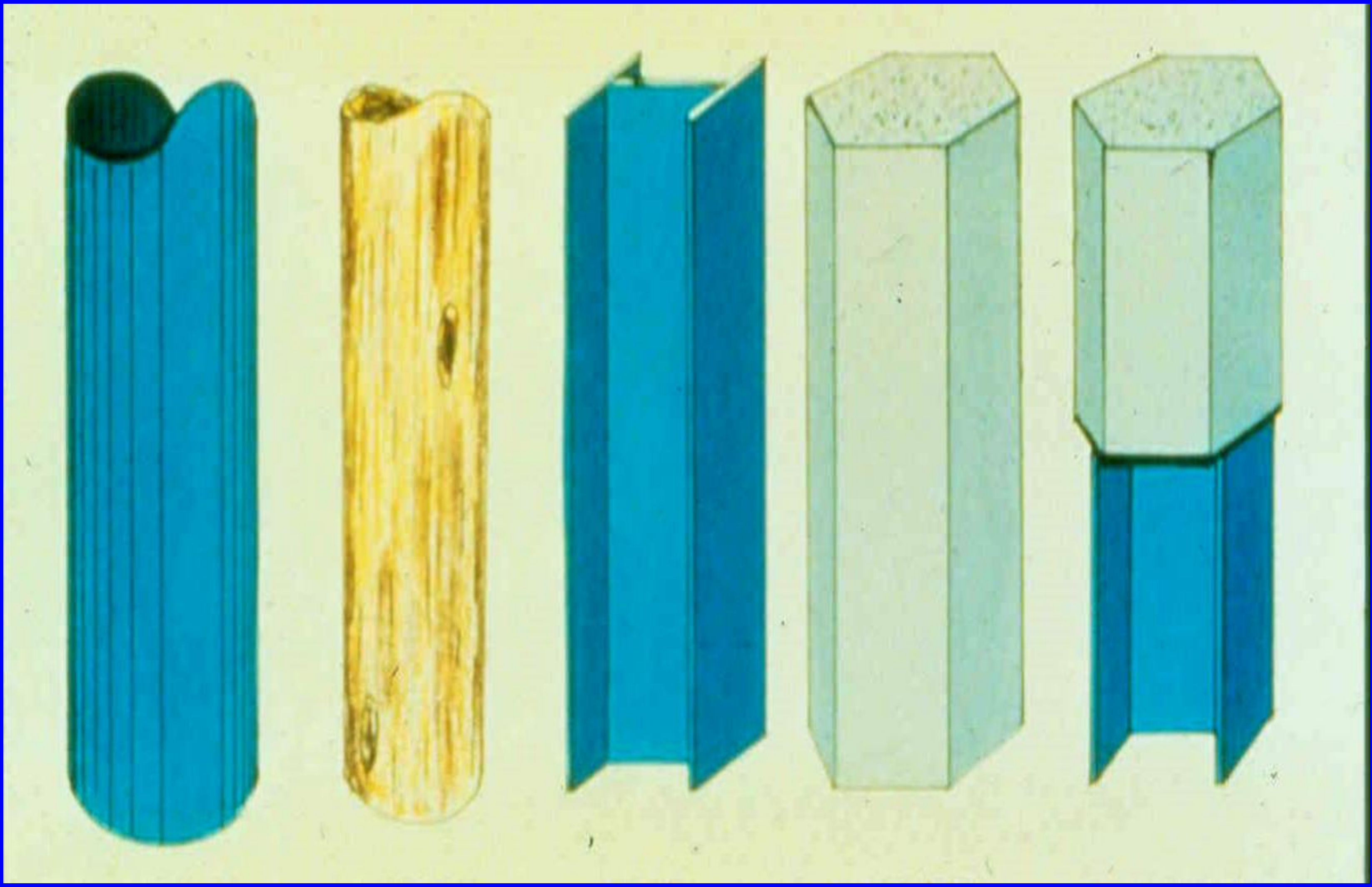
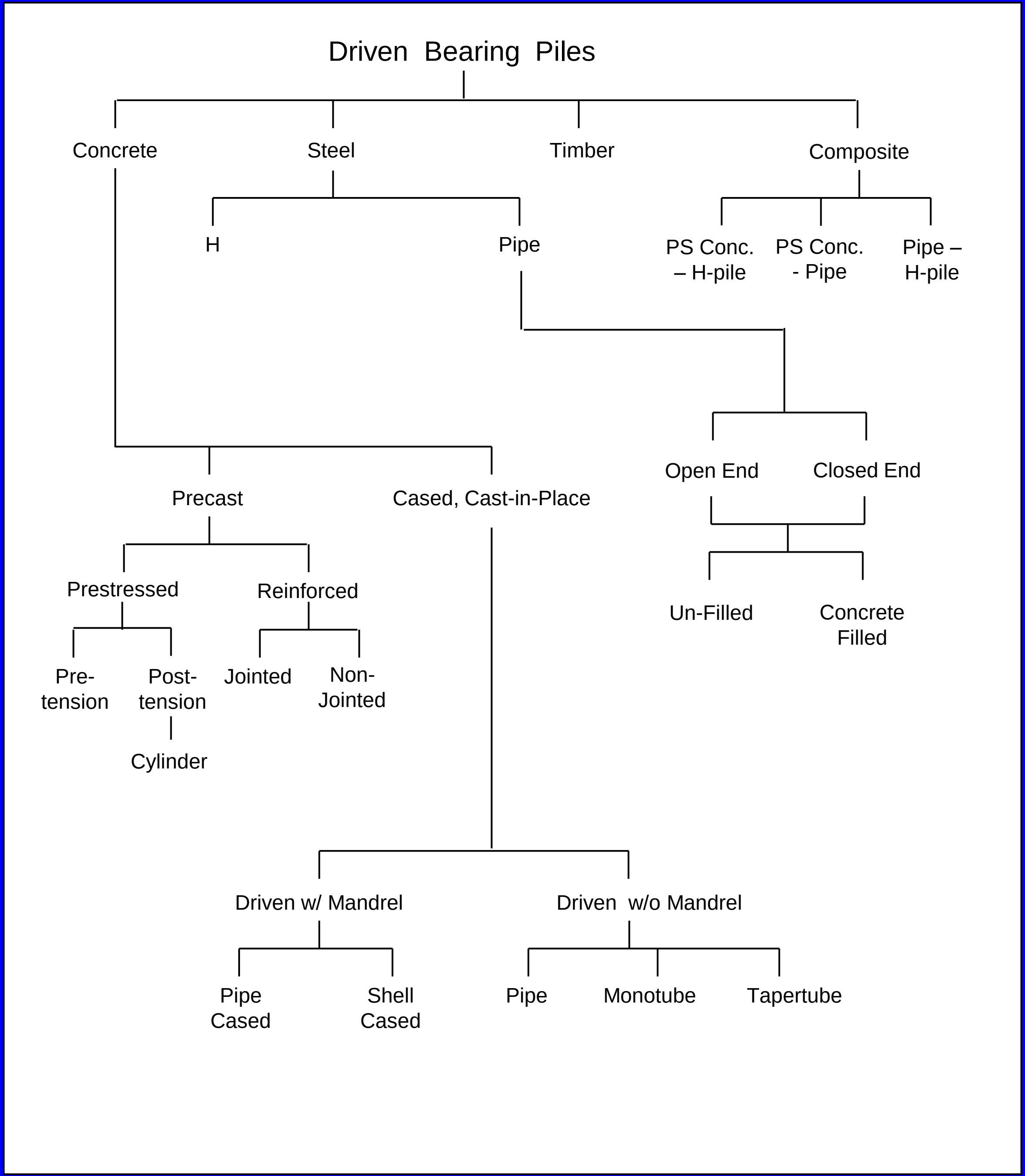
Common Driven Pile Types



Steel Pipe | Timber | Steel H | Precast Concrete | Composite

Driven Pile Classification Chart



Timber Pile Overview

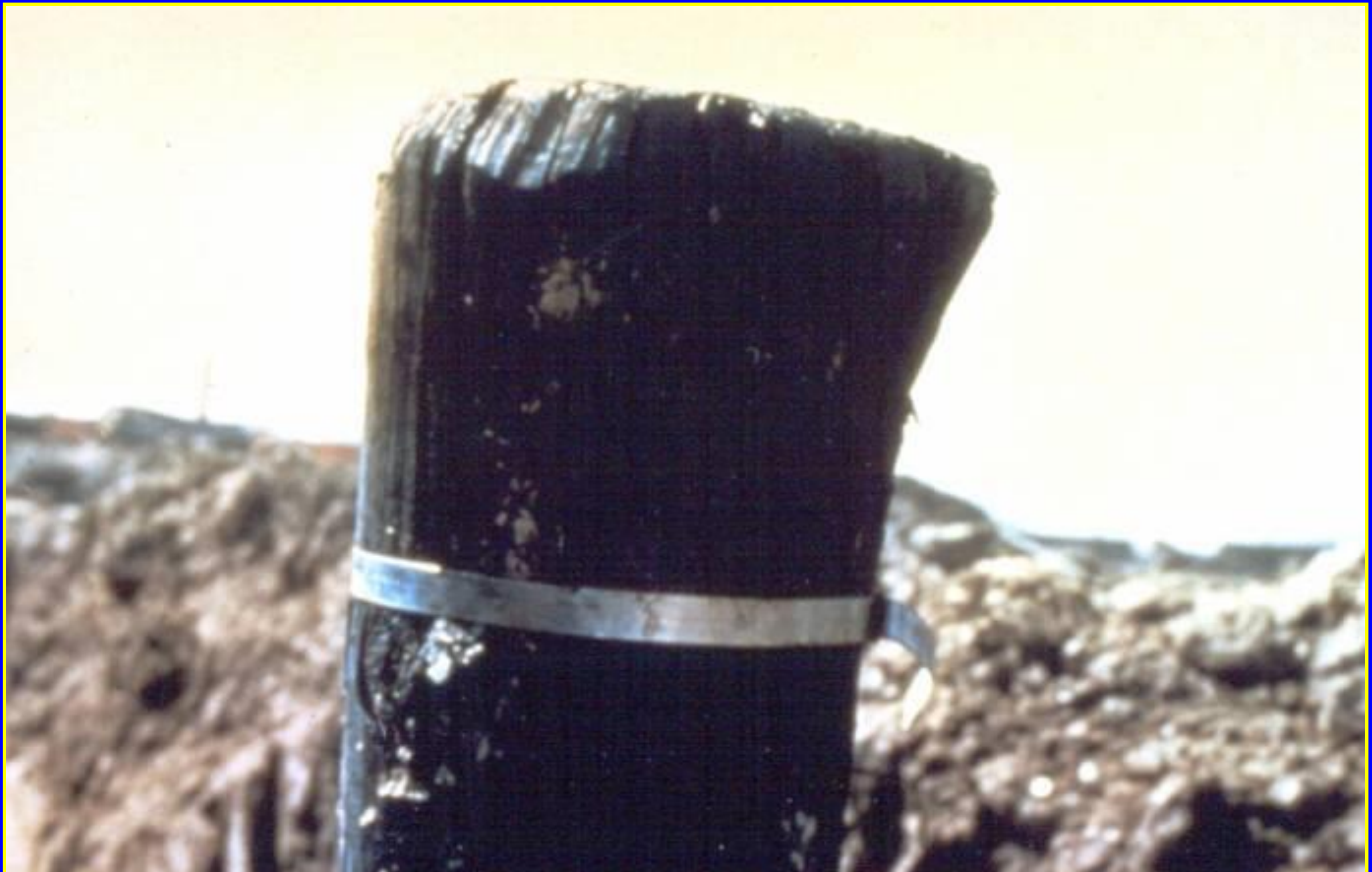
TYPICAL LENGHTS:	15 to 75 feet – Southern Pile 15 to 120 feet – Douglas Fir
MATERIAL SPECIFICATIONS:	ASTM D-25 AWPA-UC4A, 4B, 4C, 5B, and 5C
ASD:	Typical Design Stress: 0.8 to 1.2 ksi (based on pile toe area) Design Load: 20 to 100 kips (10 to 50 tons) Driving Stress: 3 x Design Stress (3 ksi +/-)
LRFD:	Factored Load: 50 to 120 kips (25 to 60 tons) Driving Stress: 1.15 x F_{co} (1.4 ksi +/-)
ADVANTAGES:	Comparatively low initial cost. Easy to handle. Permanently submerged piles resistant to decay.
DISADVANTAGES:	Difficult to splice. Vulnerable to damage in hard driving at pile head and pile toe. Vulnerable to decay if untreated and intermittently submerged.
REMARKS:	Best suited for friction pile in granular soil.

Timber Piles

Timber Piles

Timber Pile - Toe Protection

Timber Pile - Banding



H-Pile Overview

TYPICAL LENGHTS:	15 to 200 feet
MATERIAL SPECIFICATIONS:	ASTM A-572, A-588, or A-690 (F_Y= 50, 60 ksi) (A-572 Grade 50 is standard)
ASD:	Typical Design Stress: σ_a: 0.25 to 0.33 F_Y (12.5 to 16.5 ksi) Design Load: $\sigma_a A_s$: 132 to 993 kips (HP 8x36 to HP 18x204) Driving Stress: 0.90 F_Y (45.0 ksi)
LRFD:	Factored Load: 310 to 1800 kips Driving Stress: $\phi_{da} F_Y = 0.90 F_Y$ (45.0 ksi)
ADVANTAGES:	Available in various sizes, sections and lengths. Easy to splice. High capacities possible. Low soil displacements. Pile toe protection may assist in penetrating harder layers or some small obstructions.
DISADVANTAGES:	Vulnerable to corrosion where exposed. HP sections can be damaged or deflected by major obstructions.
REMARKS:	Best suited for toe bearing on rock. HP sections tend to “run” in granular deposits.

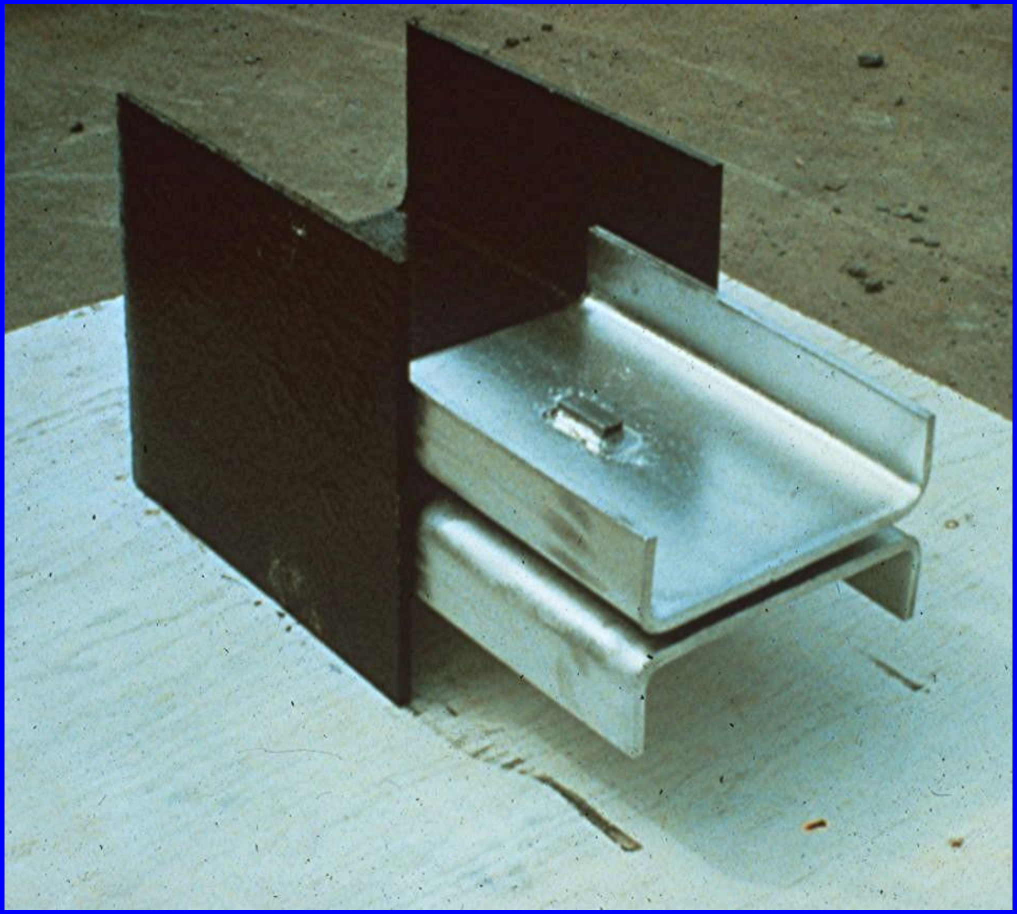
H-Piles

New Larger H-Pile Sections

H-Pile - Toe Protection

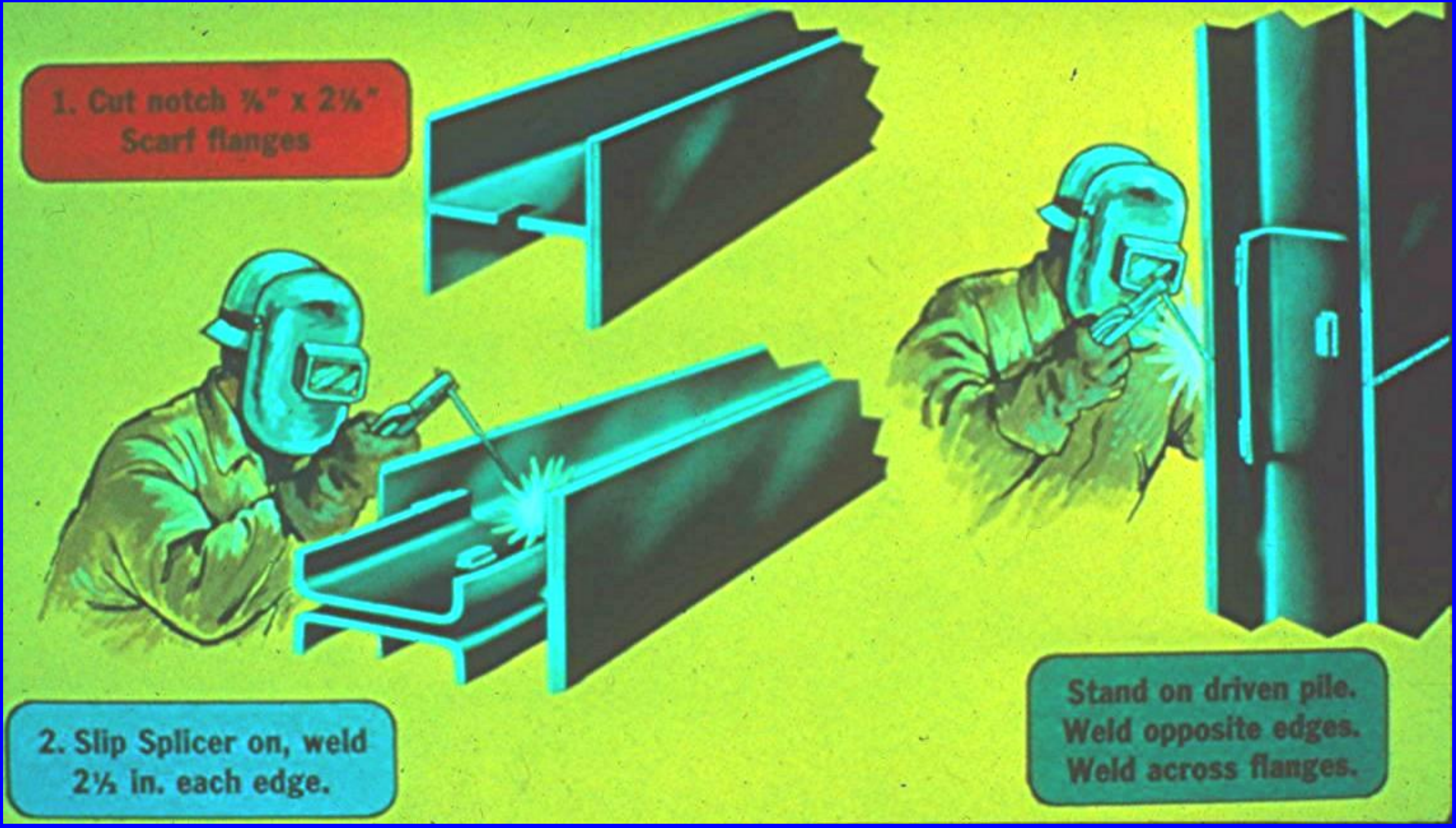
H-Pile - Splices

Full Penetration
Groove Weld



H-pile Splicer

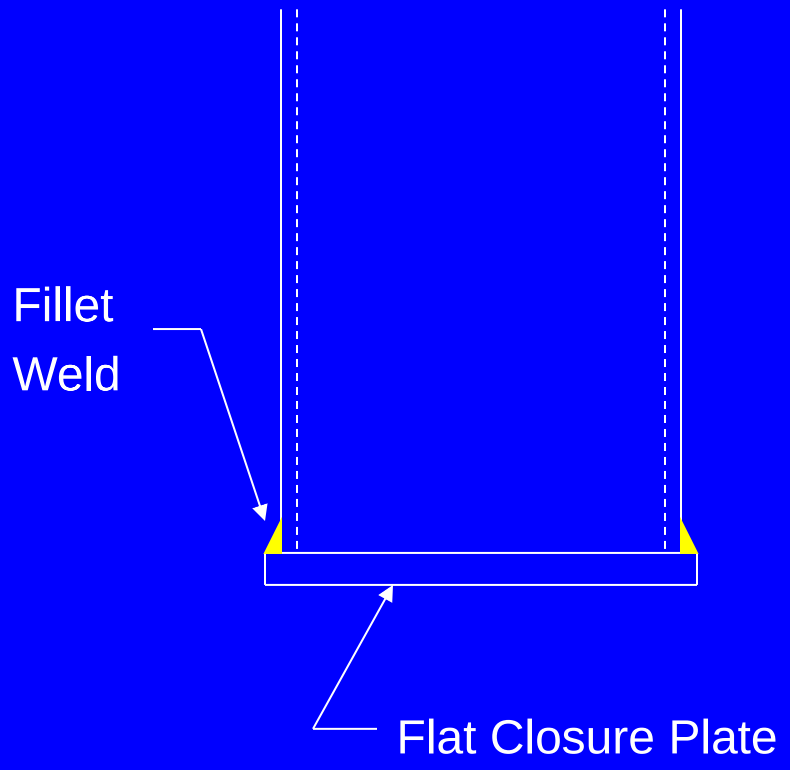
H-Pile - Splices



Pipe Pile Overview

TYPICAL LENGHTS:	15 to 200 feet
MATERIAL SPECIFICATIONS:	ASTM A-252, Grade 2 or 3 (F_Y= 35, 45 ksi), API 5L (F_Y= 42 to 80 ksi) ACI 318 – for concrete (if filled) ASTM A-572 – for core (if used)
ASD:	Design Stress: σ_a = 0.25 to 0.33 F_Y (on steel) + 0.40 f'c (on concrete) Design Load: 100 to 3,400 kips Driving Stress: 0.90 F_Y (31.5 to 40.5 ksi) or (37.8 to 72.0 ksi)
LRFD:	Factored Load: 100 to 1250 kips (closed end) with concrete fill 365 to 4,000 kips (open end) without concrete fill Driving Stress: ϕ_{da} F_Y = 0.90 F_Y (31.5 to 72.0 ksi)
ADVANTAGES:	Available in various lengths, diameters, wall thicknesses and strengths. High capacities possible. Easy to splice. Closed end can be internally inspected after driving. Open end pipe can be cleaned out and driven deeper. Open end pipe has low soil displacements.
DISADVANTAGES:	Vulnerable to corrosion. Soil displacement for large, closed end pipe
REMARKS:	High bending resistance on unsupported length.

Typical Pipe Pile Closure Plate



Conical Pipe Pile Tip

Outside Cutting Shoe

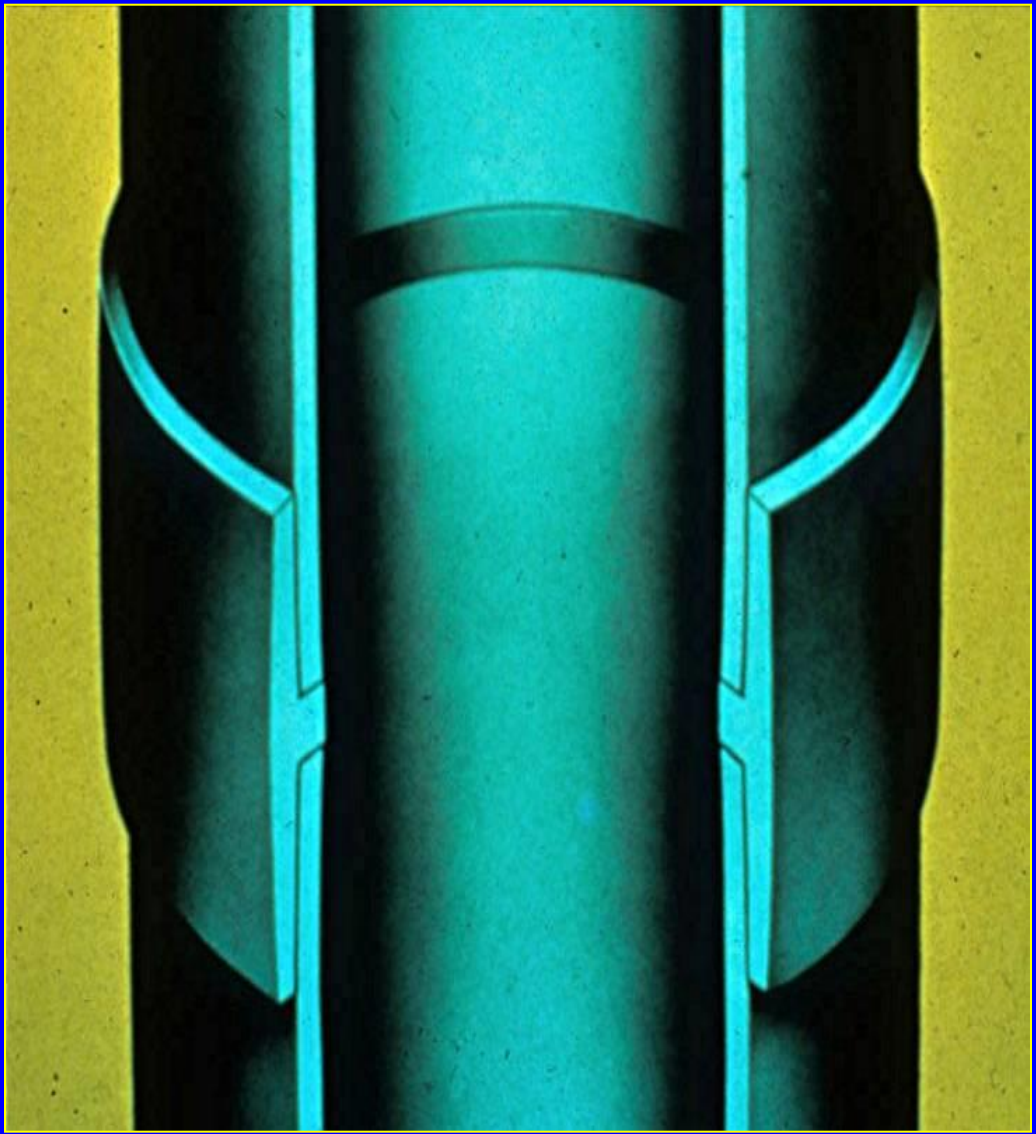
Inside Cutting Shoe

Large Diameter Open End Pipe

Spin Fin Pile

Pipe Pile - Splicing

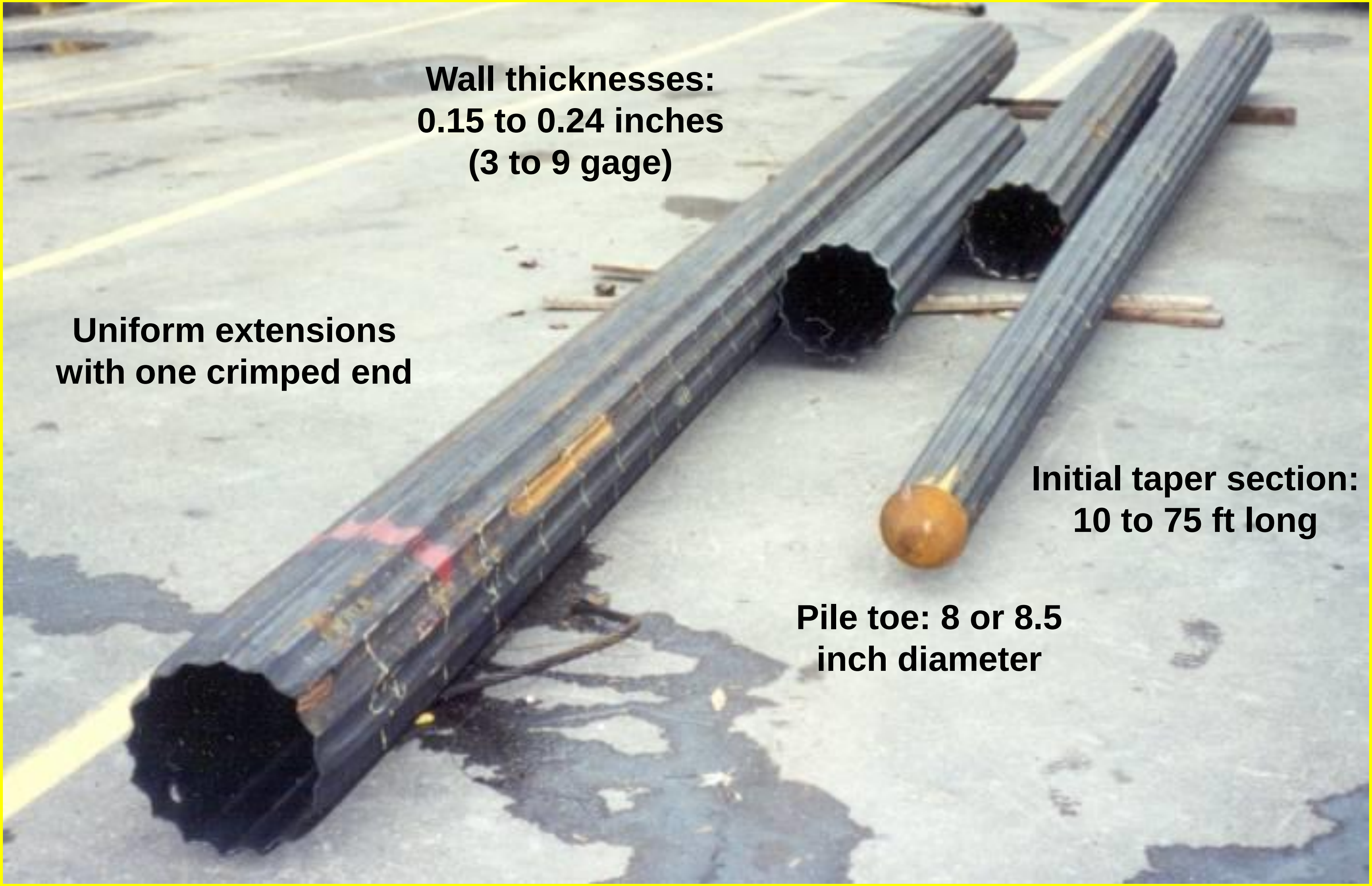
Pipe Pile - Splicing



Monotube Pile Overview

TYPICAL LENGHTS:	15 to 100 feet
MATERIAL SPECIFICATIONS:	SAE-1010 - for steel (F_Y= 50.0 ksi) ACI 318 - for concrete
ASD:	Typical Design Stress: σ_a = 0.25 F_Y (on steel) + 0.40 f'c (on concrete) Design Load: 100 to 300 kips Driving Stress: 0.90 F_Y (45.0 ksi)
LRFD:	Factored Load: 100 to 450 kips Driving Stress: 0.90 F_Y (45.0 ksi)
ADVANTAGES:	Can be inspected after driving. High capacity for relatively shorter lengths. Tapered pile section provides high resistance in granular soils. Reduced concrete fill volume in tapered pile section.
DISADVANTAGES:	Potential soil displacement effects.
REMARKS:	Best suited for friction pile of medium length.

Monotube Piles



Monotube Splicing

Cut V Notches at 90˚

Grind V Notches

Fillet Weld

Tapertube Pile Overview

TYPICAL LENGHTS:	50 to 150 feet
MATERIAL SPECIFICATIONS:	ASTM A-252, Grade 3 (F_Y= 45.0 ksi) ACI 318 – for concrete
ASD:	Typical Design Stress: $\sigma_a = 0.25\ F_Y$ (on steel) + 0.40 f'c (on concrete) Design Load: 200 to 420 kips Driving Stress: 0.90 F_Y (40.5 ksi)
LRFD:	Factored Load: 200 to 850 kips Driving Stress: 0.90 F_Y (40.5 ksi)
ADVANTAGES:	Can be internally inspected after driving. High capacity for relatively shorter lengths. Tapered pile section provides high resistance in granular soils. Reduced concrete fill volume in tapered pile section.
DISADVANTAGES:	Potential soil displacement effects.
REMARKS:	Best suited for friction pile in granular soils.

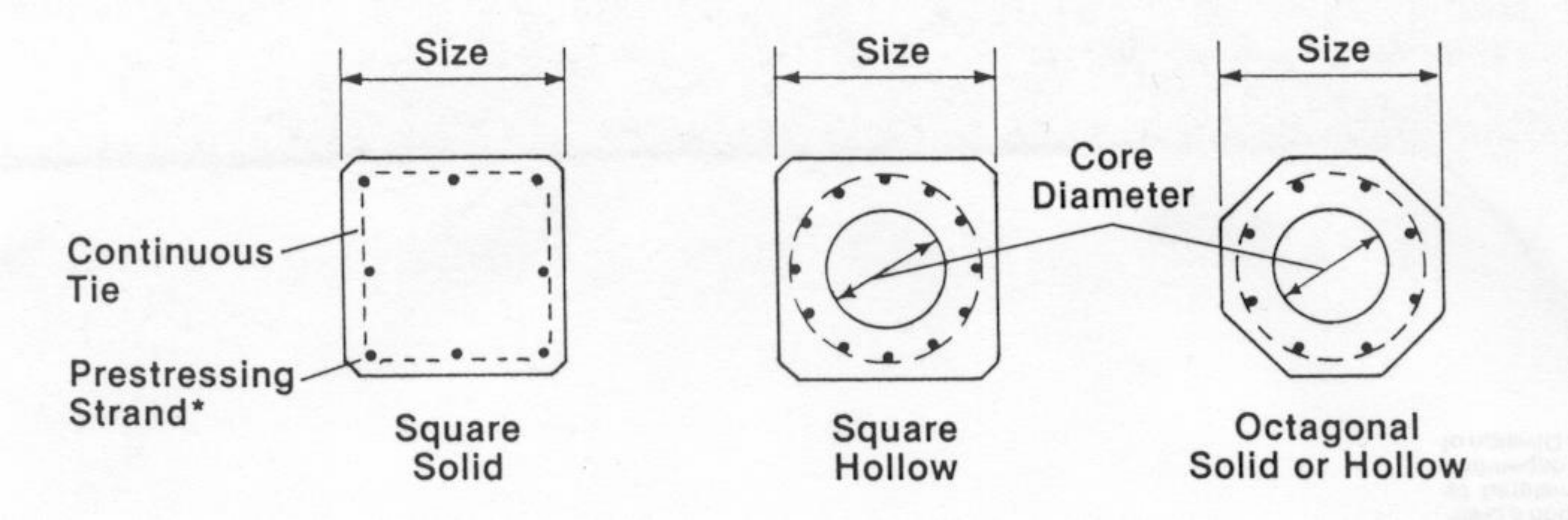
Tapertube Piles

Prestressed Concrete Overview

TYPICAL LENGHTS:	30 to 150 feet
MATERIAL SPECIFICATIONS:	ACI 318 – for concrete ASTM A-82, A-615, A-722, and A-884 for reinforcing steel. ASTM A-416, A-421, and A-882 for prestressing.
ASD:	Design Stress: 0.33 f'c – 0.27 f_{pe} (on gross concrete area) Design Load: 90 to 1000 kips Driving Stress: 0.85 f'c – f_{pe} (in compression) 3 $\sqrt{f'c}$ + f_{pe} (in tension, f'c in psi)
LRFD:	Factored Load: 350 to 2,200 kips on solid sections. 1,500 to 3,000 kips on spun cast cylinder piles. Driving Stress: 0.85 f'c – f_{pe} (in compression) 3 $\sqrt{f'c}$ + f_{pe} (in tension, f'c in psi)
ADVANTAGES:	High load capacity. Corrosion resistance obtainable. Hard driving possible.
DISADVANTAGES:	Can have relatively high breakage rate. Potential soil displacement effects from large sections. Difficult to splice when insufficient length ordered.
REMARKS:	Cylinder piles well suited for bending resistance.

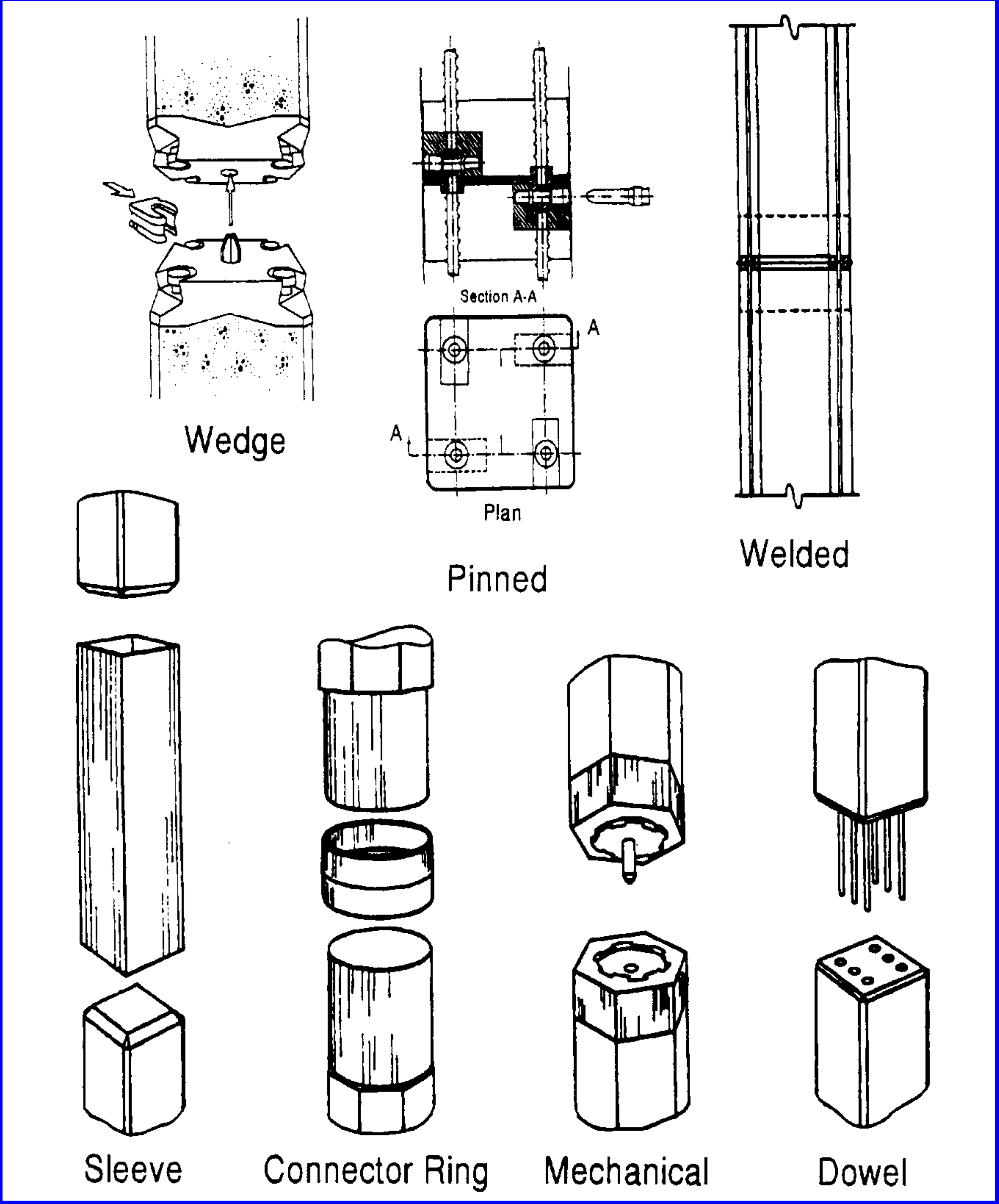
Prestressed Concrete

Prestressed Concrete Details



Typical Sizes	10 – 20 inch	20 – 36 inch 11 – 18 inch void	10 – 24 inch 11 – 15 inch void

Concrete Pile Splices



KIE-LOCK Mechanical Splice

Epoxy-Dowel Splice

Prestressed Concrete - Cutoff

Spun Cast Concrete Cylinder Piles

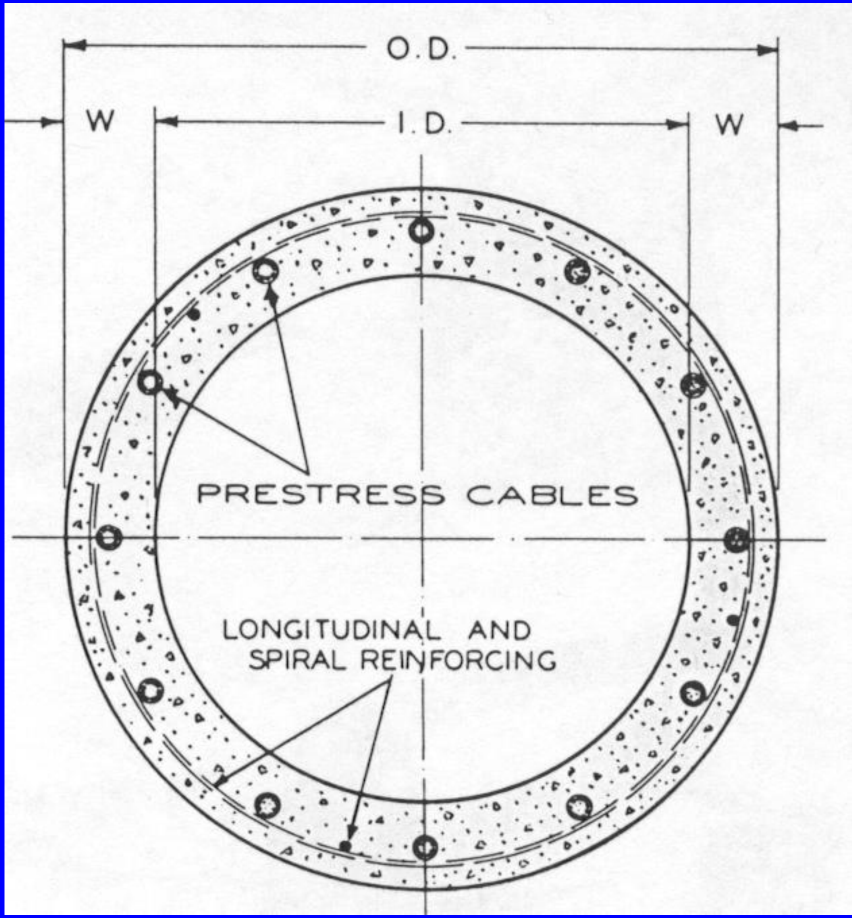
Spun Cast Concrete Cylinder Piles

<u>Pile Properties</u>

High strength concrete, f'c = 7 ksi, f_{pe} = 1.2 ksi

16 ft long pile segments (typical)

Segments combined and post-tensioned



<u>Typical Sizes</u>

36, 42, 48, 54, & 66 inch O.D.

5 & 6 inch wall

<u>Typical Design Loads</u>

250 to 800 tons

ICP Spun Cast Pile

Pile Properties

High strength concrete

$f'c$ = 10 ksi, f_{pe} = 1 ksi

20 to 120 ft long segments

Welded pile splice

Typical Pile Sizes

9.8 to 47.2 inch O.D.

2.2 to 5.9 inch wall

Typical Design Loads

80 to 1100 tons

ICP Spun Cast Pile

Composite Piles - Overview

TYPICAL LENGHTS:	50 to 200 feet.
MATERIAL SPECIFICATIONS:	ASTM A-572 for H-pile sections ASTM A-252 for pipe pile sections ACI 318 – for concrete ASTM D25 for timber sections
MAXIMUM STRESSESS:	Typical Design Stress: Depends on pile materials Driving Stress: Depends on pile materials
TYPICAL DESIGN LOADS:	30 to 200 tons
ADVANTAGES:	May solve unusual design or installation problems. High capacity may be possible depending on pile materials. May reduce foundation costs.
DISADVANTAGES:	May be difficult to attain god joint between pile materials.
REMARKS:	Weakest pile material controls allowable stresses and capacity.

Composite Piles

Concrete – H-pile

Pipe – H-pile

Composite Piles

Pipe - Concrete

Corrugated Shell - Timber

Other Pile Selection Considerations

- Site and access considerations.
- Subsurface considerations.
- Pile shape considerations.
- Drivability considerations.

Site Considerations on Pile Selection

Impact of vibrations on nearby structures.

Remote areas may restrict equipment size.

Local availability of pile materials and capabilities of local contractors.

Waterborne operations may dictate use of shorter pile sections.

Steep terrain may make use of certain pile equipment costly or impossible.

Subsurface Effects on Pile Selection

Typical Problem	Recommendation
Boulders over Bearing Stratum	Use Heavy Low Displacement Pile With Shoe. Include Contingent Predrilling Item in Contract.
Loose Cohesionless Soil	Use Tapered Pile to Develop Maximum Shaft Resistance.
Negative Shaft Resistance	Avoid Batter Piles. Use Smooth Steel Pile to Minimize Drag Load or Use Bitumen Coating or Plastic Wrap. Could Also Use Higher Design Stress.
Deep Soft Clay	Use Rough Concrete Piles to Increase Adhesion and Rate of Pore Water Dissipation.

Subsurface Effects on Pile Selection

Typical Problem	Recommendation
Artesian Pressure	Hydrostatic Pressure May Cause Collapse of Mandrel Driven Shell Piles and Thin Wall Pipe. Pile Heave Common on Closed End Pipe.
Scour	Adequate Pile Capacity Should be Developed Below Scour Depth (Design Load x SF). Tapered Pile Should Be Avoided Unless Taper Extends Below Scour Depth.
Coarse Gravel Deposits	Use Prestressed Concrete Piles Where Hard Driving is Expected.

Pile Shape Effects on Pile Selection

Shape Characteristic	Pile Types	Placement Effects
Displacement	Closed End Steel Pipe	Increase Lateral Ground Stress.
		Densify Cohesionless Soils.
	Prestressed Concrete	Temporarily Remolds and Weakens Cohesive Soils.
		Setup Time for Large Pile Groups in Sensitive Clays May Be Up To Six Months.

Pile Shape Effects on Pile Selection

Shape Characteristic	Pile Types	Placement Effects
Low Displacement	Steel H-pile	Minimal Disturbance to Soil.
	Open End Steel Pipe	Not Recommended for Friction Piles in Coarse Granular Soils. Piles Often Have Low Driving Resistances in These Deposits Making Field Capacity Verification Difficult Resulting in Excessive Pile Lengths Installed.

Pile Shape Effects on Pile Selection

Shape Characteristic	Pile Types	Placement Effects
Tapered	Timber Monotube Tapertube Thin Wall Shells	Increased Densification of Soil. High Capacity for Short Penetration Depth in Granular Soils.

Final Pile Selection

- Each type has advantages and disadvantages.
- Several pile types or sections may meet the project design requirements.
- All candidate pile types should be carried forward in the design process.
- Final pile selection should be based on the most economical pile section meeting all the design requirements.

Questions

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