Cranes
Cranes

Mobile Cranes

- Mechanical or hydraulic types
- Mechanical also referred to as “conventional” crane
- Mechanical cranes have greater capacity
- Hydraulic cranes have greater mobility and require less setup time
Cranes

Mobile Cranes

- Lattice boom or telescopic boom
- Crane capacity is controlled by its operating radius
- Operating radius is:
  - horizontal distance from center of rotation to the hook
  - a function of boom length and boom angle with the horizontal
Cranes

Mobile Cranes

- Other factors that influence capacity:
  - position of boom with respect to the carrier i.e.: over the front vs. over the rear or sides
  - amount and configuration of the counterweight
  - condition of the supporting surface
  - tire capacity (stationary and pick & carry)
Cranes

**Lifting Data**

- Crane manufacturers provide lifting data that includes:
  - Range diagram
  - Load rating charts
  - PCSA Rating Class
  - Miscellaneous notes and dimensions
Cranes

Lifting Data

• PCSA Rating Number
  – first number indicates the operating radius for nominal capacity
  – second number indicates the rated load (in hundreds of pounds) at a 40’ operating radius using a 50’ boom
  – all loads are taken in the direction of least stability with outriggers set
  – good way to compare apples with apples
Cranes

**Lifting Data**

- **Load Rating Charts**
  - lifting capacities based on \( \leq 85\% \) of tipping load on outriggers
  - lifting capacities based on \( \leq 75\% \) of tipping load on tires and crawlers
  - hook blocks, slings, spreaders, and other lifting devices are part of the load \( \therefore \) include as part of the maximum safe load or deduct their weight to determine net load capacity
# Load Ratings Over 360° with Outriggers Fully Extended

## Powered Boom

<table>
<thead>
<tr>
<th>Powerbooom Length in Feet</th>
<th>34°</th>
<th>40°</th>
<th>45°</th>
<th>55°</th>
<th>65°</th>
<th>75°</th>
<th>84.6°</th>
<th>110°</th>
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</thead>
<tbody>
<tr>
<td><strong>Radius in Feet</strong></td>
<td><strong>POUNDS</strong></td>
<td><strong>POUNDS</strong></td>
<td><strong>POUNDS</strong></td>
<td><strong>POUNDS</strong></td>
<td><strong>POUNDS</strong></td>
<td><strong>POUNDS</strong></td>
<td><strong>POUNDS</strong></td>
<td><strong>POUNDS</strong></td>
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<tr>
<td>10</td>
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<td>72 81000</td>
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<td>12</td>
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<td>67 81500</td>
<td>70 76500</td>
<td>74 69000</td>
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<td>53 54000</td>
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<td>69 34400</td>
<td>72 29900</td>
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<td>90 3700</td>
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<td>100 2600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>90 2600</td>
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</table>

PCSRA Rating Class 10 - 211
# Deductions to Be Made from Load Ratings (in Pounds)

<table>
<thead>
<tr>
<th>Description</th>
<th>Without Hook Block on Boom Point</th>
<th>Hook Block on Powered Boom</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>8.5 - 20 Ton</td>
<td>50 Ton</td>
</tr>
<tr>
<td><strong>Hook Block Weight</strong></td>
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<tr>
<td><strong>35 FT. LATTICE EXTENSION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stowed</td>
<td>580</td>
<td>950</td>
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<tr>
<td>Erected Only</td>
<td>600</td>
<td>1000</td>
</tr>
<tr>
<td>8.5 Ton Ball</td>
<td>3650</td>
<td>4000</td>
</tr>
<tr>
<td>20 Ton Block</td>
<td>4850</td>
<td>5200</td>
</tr>
<tr>
<td><strong>60 FT. LATTICE EXTENSION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stowed</td>
<td>600</td>
<td>950</td>
</tr>
<tr>
<td>Erected Only</td>
<td>5650</td>
<td>6000</td>
</tr>
<tr>
<td>8.5 Ton Ball</td>
<td>6850</td>
<td>7250</td>
</tr>
<tr>
<td>20 Ton Block</td>
<td>8250</td>
<td>8600</td>
</tr>
<tr>
<td><strong>35 - 60 FT. LATTICE EXTENSION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erected Only</td>
<td>5650</td>
<td>6000</td>
</tr>
<tr>
<td>8.5 Ton Ball</td>
<td>7300</td>
<td>7700</td>
</tr>
<tr>
<td>20 Ton Block</td>
<td>9250</td>
<td>9600</td>
</tr>
</tbody>
</table>

**Note:** These load deductions apply only to P&H supplied equipment.
Tower Cranes

- Heavy lifting for tall buildings
- Max. unsupported height typically 265’ (80 m)
- Much greater heights when supported by building’s framework
Tower Cranes

- Max. reach 230’ (70 m)
- Max. lift 19.8 Tons (18t)
- Counter weight = 20 Tons
- Maximum load-moment = 300 tonne-meter ex.: 30m (100’) radius yields a 10t lifting capacity
- Limit switches for max. load & load-moment
Tower Cranes

- Mast anchor-bolted to 30’ x 30’ x 4’ pad
- Concrete pad weighs over 500,000#’s
- Mast sections are typically 20’ x 10’ square
Tower Cranes

- Slewing unit mounts at top of mast (tower)
- Cat-head, jib, trolley, machinery arm, ties, & operator's cab
- Machinery arm contains motors, electronics, cable drum, and counter weight
Utility Construction

- Underground vs. aerial
- Public & private
- Transmission, distribution, or service
- Work sometimes performed on “live or hot” energized electric lines or pressurized water or gas lines.
Utility Construction

Utilities include:

• Electric - aerial or UG
• Communication
  – Telephone, CATV, traffic and railroad signal
• Water
• Natural gas & petroleum
• Sanitary sewer
• Storm sewer & streams
Utility Construction

Aerial Utilities -- Electric:
• Supported on poles or towers
• Electric cable – bare or insulated
• Primary electric is 3-phase ranging from 12,000 volts to 500,000 volts
• Current can jump to objects i.e. crane or excavator booms depending on the distance and relative humidity
Utility Construction

Aerial Utilities - Electric:

- Maintain a minimum 10’ distance between equipment and high voltage wire
- Secondary electric is used to feed individual customers and street lighting
- Service drops are 3-wire aerial connection from the street to the customers service head
Utility Construction

Aerial Utilities - Electric:

- Service can also be provided underground from a riser at the nearest pole
- Service drop should have a drip loop to prevent water from entering service
- Grounding of permanent and construction equipment is critical for safety
Utility Construction

Aerial Utilities- Electric:

- Towers should be grounded to drain induction charge
- De-energized conductors should also be grounded
- Pole lines are generally located within the R/W for public utilities
- Line pole (unless they are end poles) usually do not require guying
Utility Construction

Aerial Utilities:

- Corner poles (even with modest breaks) require guying or stiff-backs
- Down guys or aerial guys
- Positioning of anchors is critical
- Position on pole is primary, secondary, telephone, and CATV
Utility Construction

Underground Utilities:

• A myriad of systems installed during various points in time
• Some locations known, other not known
• Urban environments have a high density of buried utilities
• UG utilities add to the cost and risk of excavation
Utility Construction

*Underground Utilities:*

- Various codes stipulate clearances between the different utilities
- New construction employees underground distribution to a great extent
- New transmissions & distribution lines are often placed in utility corridors
- Underground is generally much more expensive than aerial
Utility Construction

**Underground Utilities:**

- Electric and telephone cable can be:
  - Direct burial cable
  - Placed in metal or PVC conduit or ducts
  - Encased in concrete
- Multiple cables run in duct banks
- Conductors are insulated
Utility Construction

Underground Utilities:
- Depth of cover dictated by spec or NEC
- Telephone cables are either copper or fiber optic.
- Interruption of any service can be expensive, but telephone is the most costly
- Splicing telephone cable is labor-intensive and time-consuming
Utility Construction

Underground Utilities:

• Cable can be installed by trenching
• Conduit and pipe can be installed by open cut, trenching (small diameter), jacking, and directional boring
• Splicing occurs in manholes, junction wells, pedestals, or CEV’s
Utility Construction

**Underground Utilities:**
- Natural gas transmission – high pressure; distribution – low pressure
- Steel or plastic pipe
- Cathodic protection system installed on steel pipe to deter corrosion
- Pipe is often coated or wrapped in a mastic membrane
Utility Construction

Underground Utilities:

- Modern water distribution in ductile iron pipe (DIP) or PVC
- Service piping: copper, PVC, polybutylene
- Antiquated systems still in service include: galvanized steel, transite (asbestos cement), and even wood!
Utility Construction

**Underground Utilities:**

- Line valves provide isolation to portions of the main
- Corporation stops are tapped directly into the main at each point of service
- Curb stop is a valve at the property line
Utility Construction

Underground Utilities:

- Sanitary sewer is usually gravity flow but can also be forced (lift or ejector pump)
- Modern pipe is DIP, PVC, or ABS
- Old systems include terra cotta (clay), lead
- Large systems may be concrete or brick structures
Utility Construction

*Underground Utilities:*

- Laterals leave building and tie into trunk line
- Trunk lines tie into larger mains
- Sewer lines intersect at manholes
- Invert elevations are critical
- Proper line and grade control is paramount
- Bedding, placing, and backfilling sewer lines must be done correctly to prevent future settlement or displacement
Utility Construction

Underground Utilities:

• Storm sewer systems also depend on gravity for flow
• Pipe includes RCP, CMP (galvanized steel or alum.), PVC/ABS/polyethylene
• Culverts carry storm or stream flow
Utility Construction

Underground Utilities:

- Drainage structures include inlets or catch basins, manholes, junction boxes, and headwalls
- Modern systems often included treatment systems such as “Bay Savers” (Refer to www.baysaver.com)
Utility Construction

Utility Construction – UG Priority of Installation

1. Sanitary Sewer – deep, critical gravity flow
2. Storm Sewer – less critical gravity flow
3. Water – pressurized flow requiring installation below frost line
4. Gas – pressurized flow, minimum safe cover
Utility Construction – UG Priority of Installation

5. Electric – flexible installation requiring safe location

6. Telephone – more flexible than electric

7. CATV and other communication have lowest priority (usually possesses least danger and expense to repair)
Utility Construction

Utility Construction – UG Color Codes

WATER
NATURAL GAS
ELECTRIC
COMMUNICATIONS
SANITARY SEWER

BLUE
YELLOW
RED
ORANGE
GREEN
Utility Construction

.........trench incompatibility

Sanitary Sewer ☹ Water

Gas ☹ Electric
Precast Structures
Manholes

- Sanitary Sewer
- Storm Drainage
- Pump Station Wet Wells
Fittings

- Bends
- Saddle Tees
Gravity Pipe

- Sewers
- Storm Drainage
- Roadway Culverts
Box Culverts

- Storm Drainage
- Roadway Culverts
- Tunnels
- Bridges
Preparation of Firm Bed

6" Minimum Granular Material
Form & Tie Steel for Floor
Set Up Form Work
Set Box Sections
Immediate Backfill & Open Roadway
Placing hotmix pavement over culvert
Setting Precast Sections
Setting Box Sections
Figure 3  Standard Trench Installations

- Overfill Soil Category I, II, or III
- Excavation line as required
- Haunch - See Table
- Lower Side See Table
- Bedding See Table
- Middle Bedding loosely placed uncompacted bedding except for Type 4
- Foundation
- D₁
- D₀/3
- D₀/6 (Min.)
- D₀ (Min.)
- Springline
- Outer Bedding materials and compaction each side, same requirements as haunch

Detailed annotations and measurements for a standard trench installation diagram.
<table>
<thead>
<tr>
<th>Installation Type</th>
<th>Bedding Thickness</th>
<th>Haunch and Outer Bedding</th>
<th>Lower Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>$D_0/24$ minimum, not less than 75 mm (3&quot;). If rock foundation, use $D_0/12$ minimum, not less than 150 mm (6&quot;).</td>
<td>95% Category I</td>
<td>90% Category I, 95% Category II, or 100% Category III</td>
</tr>
<tr>
<td>Type 2</td>
<td>$D_0/24$ minimum, not less than 75 mm (3&quot;). If rock foundation, use $D_0/12$ minimum, not less than 150 mm (6&quot;).</td>
<td>90% Category I or 95% Category II</td>
<td>85% Category I, 90% Category II, or 95% Category III</td>
</tr>
<tr>
<td>Type 3</td>
<td>$D_0/24$ minimum, not less than 75 mm (3&quot;). If rock foundation, use $D_0/12$ minimum, not less than 150 mm (6&quot;).</td>
<td>85% Category I, 90% Category II, or 95% Category III</td>
<td>85% Category I, 90% Category II, or 95% Category III</td>
</tr>
<tr>
<td>Type 4</td>
<td>$D_0/24$ minimum, not less than 75 mm (3&quot;). If rock foundation, use $D_0/12$ minimum, not less than 150 mm (6&quot;).</td>
<td>No compaction required, except if Category III, use 85% Category III</td>
<td>No compaction required, except if Category III, use 85% Category III</td>
</tr>
</tbody>
</table>
Actual Installation

Trenching Shield

4 inches

2 Ft 2 Ft 2 Ft

Initial density after compaction 95%

After removing shield 82%

Need the rigidity and strength of RCP to overcome the decrease in density
Construction Standards
For Excavation
(29 CFR Part 1926.650-.652)
Subpart P

• Applies to trenches
  – > 5’ ≤ 20’ deep
  – < 15’ wide at the base
  – exception = in only stable rock
• 80% fatalities occur in trenches < 12’
• 30% occur in trenches < 8’
Construction Standards for Excavation
(29 CFR Part 1926.650–.652)
Subpart P

• Requires a “Competent Person” be present on site and provide inspections:
  – daily
  – after every rainstorm
  – anytime conditions change
Construction Standards For Excavation

• Inspecting for:
  – possible cave-ins
  – protection system failures
  – hazardous atmosphere
  – falling objects
  – enforcement of safety policy & procedures
  – any other hazards
Construction Standards
For Excavation

• Before you dig:
  – identify and locate all utilities
  – plan protection for workers for any active utilities that will be in the trench
  – determine if a hazardous atmosphere may exist in a trench > 4’
  – plan evacuation routes out of trenches over 4’ within 25’ of workers
Trench Excavation
Causes of Collapse

- Soft zones
- Layered soil
- Sloughing
- Vibration
- Effects of water
- Soft pockets
- Old utility crossing trench
- Fractured rock
**Trench Excavation**

*Soil Classification*

<table>
<thead>
<tr>
<th>Class</th>
<th>Compressive Strength</th>
</tr>
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<tbody>
<tr>
<td>Solid Rock</td>
<td>NA</td>
</tr>
<tr>
<td>Class A</td>
<td>&gt; 1.5 TSF (no vib/fis/lay)</td>
</tr>
<tr>
<td>Class B</td>
<td>&gt; 0.5 but &lt; 1.5 TSF</td>
</tr>
<tr>
<td>Class C</td>
<td>≤ 0.5 TSF</td>
</tr>
</tbody>
</table>
Trench Excavation

Soil Classification

**Visual**
- Grain size
- Clumping
- Tension cracks
- Layering
- Water
- Vibration

**Manual**
- Plasticity test
- Dry strength test
- Thumb test
- Drying test
- Penetrometer
Trench Excavation

Soil Classification

Plasticity Test

……….Roll a “worm” 2” x 1/8”

• If it does not work, the soil is non-cohesive Type B or C
• If it works, the soil is cohesive Type A, B, or C depending on unconfined compressive strength
Trench Excavation

Soil Classification

Dry Strength

• If the soil crumbles on its own, it is granular Type B or C
• If it the soil is hard to break into clumps and unfissured, it is Type A
Trench Excavation

Soil Classification

Thumb Penetration (unconfined compressive strength)

• Past the knuckle = Type C ≤ 0.5 TSF
• To the knuckle = Type B > 0.5 but < 1.5 TSF
• Just a dent = Type A . 1.5 TSP
Trench Excavation

Sloping/Benching Options

1.5 : 1 Slope only (34 degrees)

Bench or slope according to Appendices A & B

Slope or bench according to Appendices A & B

Designed by a Registered Professional Engineer, with a copy of the design on site
Trench Excavation

*Maximum Allowable Slope*

Stable Rock = Vertical 90° (to horizontal)

Type A Soil = 3/4 : 1 53° (to horizontal)

Type B Soil = 1 : 1 45° (to horizontal)

Type C Soil = 1.5 : 1 34° (to horizontal)
Trench Excavation

Shoring

• Timber shoring must be properly designed using Table Data (Appendices A, C or other table), or by a Professional Engineer.

• Manufactured shoring must be installed according to Manufacturer’s specifications.

• Table Data not obtained from Appendix A or C must be kept on site.
Trench Excavation

**Shielding**

- Trench boxes must be used according to the manufacturer’s specifications, or a PE
- Must be maintained
- Specifications must be kept on site
Trench Excavation

Concerns During Trench Excavation

- Placement of spoils (surcharge load)
- Location of equipment and trucks
- Diversion/control of water
- Vehicular and pedestrian traffic
- Adjacent buildings and other structures
- Protection during off hours