Arab Academy for Science, Technology & Maritime Transport
Colleague of Engineering & Technology
Construction & Building Engineering

CB 523
METHODS AND EQUIPMENT FOR CONSTRUCTION 1

Lecture 8&9

Cranes

Instructor: Dr. Ahmed Elyamany

Telescoping Boom Mobile Cranes

- Telescoping boom mobile cranes are very **economical** for making **one lift** or a **limited number** of lifts in a short period of time.
- Most of the time mobile cranes are **rented**.
- They can be driven assembled to the job or the lift site on public roads.
- This greatly **reduces the setup time and cost**.
- **Lifting capacities** and work ranges can be quite large if necessary, but most lifting is **light** to **medium**.

Lattice Boom Crawler Cranes

- Lattice boom crawler cranes are very **common on most types** of construction projects.
- They are versatile in that many attachments to perform many different types of work such as **draglines** and **clamshells** for excavation, **pile drivers**, dynamic **compactors**, "**wrecking**" balls for demolition, **augers** for drilling holes, and **magnets** for moving metal objects can be easily attached and used.
- There are several boom configurations that can be used.

Lattice Boom Crawler Cranes

- A crawler tower crane is **less costly than a tower crane**.
- The main boom is vertical with a luffing boom attachment.
- The compressive load is transferred to the crane cab and counterweights down this vertical boom.
- Maximum boom and jib combination are approximately **480 ft**.

Lattice Boom Crawler Cranes

- Because of the crawler tracks and the instability caused by the moment created at the end of the boom by the load, these cranes **move slowly** and must travel on a level stable surface.
- This **road surface** must be **level** and **stable** enough to support the crane’s weight and also the weight of its load.

Tower Crane

- Towers have a maximum freestanding height.
- To reach higher, tower crane may be attached temporarily to the structure.
- Attaching tower crane to a structure gives the crane greater stability and the tower can be built higher.

Tower Crane

- Erecting a tower crane is a substantial construction process that requires other equipment such as **forklifts**, **crawler cranes**, or most likely, **mobile cranes**.
- Pieces are typically **hauled** to the job site by **18-wheel trailers** and then unloaded for erection.
- If the crane base is not part of a structure, a **concrete base** must be constructed prior to erection.

Tower Crane

- One of the considerations is what to do with the **crane base** after crane is **dismantled**.
- If the base is large, it could be quite **costly to remove** and haul off.
- The maximum unsupported tower height is **265 ft (80 m)**.
- The crane can have a total **height much greater** than 265 ft if it is **tied into the building** as the building rises around the crane.

Tower Crane

- The **closer the load** to the tower, the **more weight** the crane can lift safely.
- The **further the load** from the tower, the **less weight** the crane can lift safely.
- The **area of coverage** based on the lift capacity must be detailed for the whole site by reviewing the site plan.
- Sometimes **multiple towers** are necessary to get adequate coverage.
- Using **tower cranes** is **safer and more efficient** than having to **move** **crawler cranes** many times.

Tower Crane

- Crane requirements for heavy **one-time lifts** are somewhat different from the requirements for **everyday lifts** performed by most tower cranes.
- It is **cheaper** to have a **tower crane** that can lift **90%** of the loads on hand every day for an extended period of time and pay a **rental fee** for having a larger capacity crane on the job for a short time to make the other **10%** of lifts.
- These percentages should be determined and may change based on project needs.

Tower Crane

- Most project use a **combination** of crane types.
- The superintendent should be involved with the crane **supplier** or company crane **supervisor** in deciding **locations**, **capacities**, **heights**, and **numbers** of tower cranes.

Tower Crane

- Most construction companies **lease tower cranes** for the erection of the structure.
- Tower cranes are usually **leased monthly**.
- Normal use tower cranes on high-rise buildings will run between **L.E. 140,000** to **L.E. 300,000**/month.
- The **erection** and **dismantling** costs may be included as cost in the **contractor's** budget or in the **supplier's** mobilization costs.

Tower Crane

- The **rental/erection** company ships the crane to the site, assembles it, and charges a **monthly fee** while the crane is **on site**.
- Depending on the size of the crane, the typical fee for installation and disassembly amounts to around **L.E. 120,000**.
- This price includes **shipping** the crane to the site, **renting** the mobile crane used to assemble the tower crane, cost of the **crew** that handles the assembly, and other **associated** costs.

Tower Crane

- A typical monthly fee for a **150-ft** tall average capacity tower crane is approximately **L.E. 300,000**, with an additional charge to rent the climbing frame and extra mast sections if required.

LIFTING AND VERTICAL CONSTRUCTIONS

- Cranes make **"on-time"** delivery scheduling possible.
- Delivery timing can be staggered to allow time for loads to be hoisted and secured.
- This approach demands great attention to the work scheduled on a day-to-day basis.
- **How and when** the work will be performed is the basis for scheduling.
- Efficient and effective communication with suppliers or manufacturers is critical because of the importance of meeting the schedule.

LIFTING AND VERTICAL CONSTRUCTIONS

- For the operation to **run smoothly**, the truck must arrive at about the time the crane is ready to lift.
- The **truck cannot leave** until it is unloaded, therefore possibly causing traffic congestion or having to wait at a remote location.
- Most loads however, have to be **stored**, **staged**, and **rigged** before erection.
- By not setting the load down, it only has to be **rigged once**, and does not have to be moved twice, minimizing the chance of damage, no surface space is consumed for storage, and no protection or security has to be supplied.

LIFTING AND VERTICAL CONSTRUCTIONS

- **To lift safely,**
- Choose the right equipment and rigging.
- Risks of high-rise construction are greatly compounded due to lifting occurring over part of the built structure.
- The cost incurred by lifting must be estimated and included in the project budget at the time of bidding.
- Risks facing people as the height of construction increases must be minimized .
- This is a huge responsibility for all the parties involved in vertical construction.

LIFTING PRODUCTIVITY

- The steps for making a “pick” are similar for all types of lifting equipments.
- The production cycle time can be calculated by adding all steps times.
- Largest variable in the cycle time is **placement height**.
- Obviously the higher the placement, the longer it takes to get the load to the height.

LIFTING PRODUCTIVITY

Typical lifting equipment production steps are:

1. Prepare the load — secure or band, position so it can be rigged and lifted
2. Rig the load (gripping)
3. Hoist the load for movement or placement
4. Walk the load — carry the load on the ground to the placement location
5. Place the load
6. Unload the load or release the rigging (un-gripping)
7. Return for the next load

LIFTING PRODUCTIVITY

- Support workers and riggers on the ground perform steps 1 and 2.
- Riggers, ironworkers, or carpenters on the structure typically perform steps 5 and 6.
- The work efficiency of these crews has a primary influence on cycle time.
- Steps 3 and 4 are a function of the crane’s capability; lift capacity, boom length, and hoist speed.

LIFTING PRODUCTIVITY

Example of lifting production cycle is bucket-pouring concrete columns on a high-rise in a metropolitan area.

1. A bucket is rigged on the hoisting cable of a tower crane.
2. The bucket is filled with concrete from a truck at ground.
3. The boom is swung near face of building while bucket is raised.
4. The bucket is hoisted to a height that is slightly above the placement point at the top of the structure.
5. The boom is swung over the structure and the boom tip is positioned over the placement location.

LIFTING PRODUCTIVITY

6. The bucket is lowered to the appropriate column form on the structure.
7. The bucket is positioned and opened by the workers at the form.
8. When the concrete is all released, the bucket is raised and swung back over the ground loading point.
9. The bucket is lowered to the ground level and positioned to be filled again.

- As vertical hoist height increases, cycle time increase.

CONCRETE-PLACING

- **Bucket pouring** and **pumping** are two methods commonly used for placing concrete in a vertical construction.
- The selected method must take into account the **volume** of concrete to be placed, the **location** of the pour, the **expertise** of the placement crew, and the desired **production**.

BUCKET POURING

- tower cranes are typically used when operating space is limited.
- Tower cranes are ideal for bucket-pouring concrete in high-rise cast-in-place construction.

BUCKET POURING

- Bucket pouring, especially for flatwork, is done at a higher speed than normal crane operation.
- High-speed repetitive lifting production is called "**duty cycle**" operation.
- When **pumping** the concrete is not an option due to height, mix, or location, **bucket** pouring using a crane is the best solution.
- If amounts to place are **small** and **not spread out**, bucket pouring is the best option (**columns and beams**).

BUCKET POURING

- Tower crane bucket pouring production is based on several considerations:

I. Setup for “chuting” the concrete into the bucket should be accessible to the crane and the concrete delivery truck.

II. Ease of rigging or unrigging the bucket. Typically the bucket will stay rigged to the hoist line until the pour is complete. Bucket capacity about 1.5–3 cubic yards (5,850 – 11,700 lbs).

BUCKET POURING

III. The speed at which the hoist line is raised or lowered and the speed of the boom swing cause variability in production cycle times.
IV. Unloading the bucket is a variable time in the production cycle.

Example 8.1

A free standing, top slewing, standard configuration, **Liebherr tower crane** secured in a concrete foundation base is hoisting a **1.75 cy** bucket to pour concrete columns on a high-rise office building. The pour is a **10th floor** column. Each floor is **about** 11’6” height. The top of this column form is **6’** off the 10th floor surface. The crane capacity is verified for the lifting radius of **90’** and the setup. Normal concrete weighs about **150 lbs/cf**.

Example 8.1

150 lbs/cf(27 cf/cy) = **4050** lbs/cy

A bucket load weighs about 1.75 cy (4050 lbs/cy) = **7088** lbs.

What is the hourly production for the crane to make this pour?

Example 8.1

First the cycle components and their appropriate times must be determined:

1. The loading time on the street =**0.5 min**. The bucket is about 30’ from the tower base when loading.

2. Hoist time =lift height/line speed.

The lift height =(10 stories*11.5’/story)+6’+(10’) to clear the load over the placement point = approximately 131’.

Line speed average =120’/min **(see manufacturer’s specifications for this information).**

Hoist time =131’/(120’/min) =**1.1 min**.

Example 8.1

3. Once the load reaches approximately 131’ the boom is positioned and the load is moved along the trolley 60’ to above the placement point. This takes about **0.4 min**.

4. It takes about **0.1 min** to lower and position the bucket.

5. It takes about **0.6 min** to dump the load.

6. It takes about **1.4 min** to raise the bucket, retract the trolley 60’, lower the bucket to the street, and position for another load.

Example 8.1

Cycle time = 0.5 min + 1.1 min + 0.4 min + 0.1 min + 0.6 min + 1.4 min = 4.1 min/cycle

Use a 50-min work hour for production calculation.

Hourly production = 50 min/4.1 min/cycle

=12 cycles/h (1.75 cy/cycle) =21 cy/h.

PUMPING

- Concrete pumping is used whenever the concrete cannot be unloaded directly from the truck down a chute to the placement location.
- The concrete mix must be suitable for pumping.
- The pour could be out into the middle of a large slab on grade or over **250’** up a high rise.

PUMPING

- The **distance** to push the concrete, the **diameter** of the hose or pipe, the **type** of concrete mix, and the desired **output** determine the amount of pressure that has to be developed by the pump to place the concrete.

PUMPING

- The amount of **pressure** needed is proportionate to the **diameter** of the pipe through which the mix is pumped and the **boom** configuration and **height**.
- Pressure increase as the pump **height** or **distance** or the **diameter** of the line increases
- For **small pours**, bucket pouring may be more cost efficient than using a pump truck.
- For **large pours**, pumping is faster and more efficient.

PUMPING
Example 8.2

- A Putzmeister 58M truck mounted concrete boom pump is to be used to pour flatwork on a 10-story classroom building. It is assumed that the pump can sufficiently push the concrete mix. The vertical reach of the pump is about **188'**. It has a horizontal reach of about **174'**. The pour is at about **96'** floor level and most of the boom will be needed to cover the pour surface. The pump production is about **200 cy/h**. The concrete company has promised between five and seven 9 cy trucks/h. Two pours of **12,500 sf** (25,000 sf total) **4"**-thick 3500-psi light mix concrete are planned on consecutive days. The truck setup and priming is **$900**.

PUMPING
Example 8.2

- There is a **$125/h** charge for the truck, operator, and helper. There is a **$2/pumped cy** charge. There is no minimum time charge used in this problem, though most pumping services have a minimum time charge per setup. This example illustrates the importance of uninterrupted and adequate concrete delivery.
- **How much will the pump truck and setup cost to pump the concrete for the 25,000 sf floor? What is the unit cost for the pump truck?**

PUMPING
Example 8.2

- Total volume of concrete for the whole floor (assume no waste) = 25,000 sf *(0.33')*27 cf/cy = **306 cy**
- Volume of concrete /pour =12,500 sf *(0.33') * 27 cf/cy = **153 cy** /pour

- Daily cost for the pump truck and operator = setup + hourly charge + per yard pumped charge

PUMPING
Example 8.2

- **Use 5 trucks/h * (9 cy/truck) = 45 cy/h**
- 153 cy to be pumped/45 cy/h = 3.4 h
- Charge time = 4 h
- Total hourly charge for 5 trucks/h= 4 h * $125/h = $500
- Per yard pumped charge = 153 cy * $2/cy = $306
- Daily cost for 5 trucks/h = $900 + $500 + $306 = $1706
- Total cost for pumping the 25,000 sf for 5 trucks/h = 2 setups($1706) = $3412
- Unit cost for pumping for 5 trucks/h = $3412/25,000 sf = **$0.136/sf**

PUMPING
Example 8.2

- **Use 7 trucks/h * (9 cy/truck) = 63 cy/h**
- 153 cy to be pumped/63 cy/h = 2.5 h,
- Charge time = 3 h
- Total hourly charge for 7 trucks/h= 3 h * $125/h = $375
- Per yard pumped charge = 153 cy * $2/cy = $306
- Daily cost for 7 trucks/h = $900 + $375 + $306 = $1581
- Total cost for pumping the 25,000 sf for 7 trucks/h = 2 setups($1581) = $3162
- Unit cost for pumping for 7 trucks/h = $3162/25,000 sf = **$0.126/sf**

THANKS