CHAPTER

17

Construction Planning, Equipment, and Methods

Sixth Edition

CRANES

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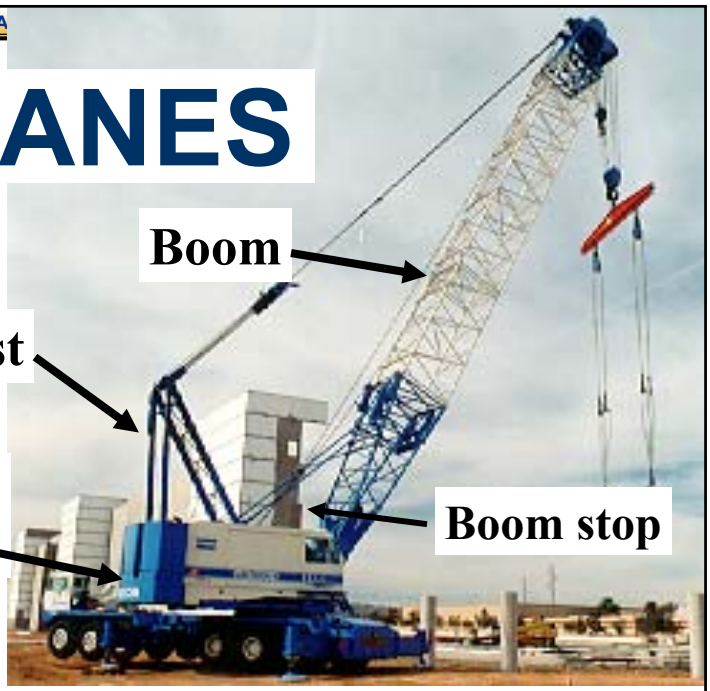
CRANES

The crane is the primary machine used for the vertical movement of construction materials.

CRANES



CRANES

- Cranes are a broad class of construction equipment used to hoist and place loads.
- Each type of crane is designed and manufactured to work economically in a specific site situation.

CRANES

- The most common types are:
  1. Crawler
  2. Hydraulic truck
  3. Lattice-boom truck
  4. Rough-terrain
  5. All-terrain
  6. Heavy lift
  7. Modified cranes for heavy lift
  8. Tower

CRANES

- The *full revolving superstructure* of this type of unit is mounted on a pair of continuous parallel crawler tracks.
- Many manufacturers have different option packages available which permit the configuration of the crane to a particular application, standard lift, tower unit, or duty cycle.
- Units in the low to middle range of lift capacity have good lifting characteristics and are capable of duty cycle work such as handling a concrete bucket.

CRAWLER CRANES

CRAWLER CRANES

CRAWLER CRANES

- Machines of 100-ton capacity and above are built for lift capability and do not have the heavier components required for duty-cycle work.
- The universal machines incorporate heavier frames, have heavy duty or multiple clutches and brakes, and have more powerful swing systems. These designs allow for quick changing of drum laggings which vary the torque/speed ratio of cables to the application.

CRAWLER CRANES

- The crawlers provide the crane with travel capability around the job site.
- The distance between crawler tracks affects stability and lift capacity.
- To be transported between projects, the crawler crane must be transported by truck, rail, or barge.

CRAWLER CRANES

- As the size of the crane increases, the time and cost to dismantle, load, investigate haul routes, and reassemble the crane increases. Transporting the largest machines can require 15 or more truck trailer units.

CRAWLER CRANES

- The crawlers usually have lower initial cost per rated lift capability, but movement between jobs is more expensive.
- Crawler-type machines should be considered for projects requiring long-duration usage at a single site.

HYDRAULIC TRUCK CRANES

- The hydraulic truck crane has a self-contained boom.
- Most units can travel on the public highways between projects under their own power with a minimum of dismantling. Once the crane is leveled at the new work site, it is ready to work without setup delays.

HYDRAULIC TRUCK CRANES

HYDRAULIC TRUCK CRANES

- If a job requires crane utilization for a few hours to a couple of days a hydraulic truck crane should be given first consideration because of its case of movement and setup.
- The hydraulic multisection telescoping boom is a permanent part of the full revolving superstructure. In this case the superstructure is mounted on a multiaxle truck/carrier.

HYDRAULIC TRUCK CRANES

- There are three common power and control arrangements for hydraulic truck cranes:
  1. A single engine as both the truck and crane power source, with a single dual position cab used both for driving the truck and operating the crane.
  2. A single engine in the carrier but with both truck and crane operating cabs.
  3. Separate power units for the truck and the superstructure. This arrangement is standard for the larger capacity units.

HYDRAULIC TRUCK CRANES

- Hydraulic truck crane units have extendable outriggers for stability. In fact, many units cannot be operated safely with a full reach of boom unless the outriggers are fully extended and the machine raised so that the tires are clear of the ground.

HYDRAULIC TRUCK CRANES

- **Remember:** All mobile cranes are stability-sensitive machines. Rated loads are based on ideal conditions, a level machine, calm air, and no dynamic effects.

LATTICE-BOOM TRUCK CRANES

- As with the hydraulic truck crane a full revolving superstructure is mounted on a multiaxle truck/carrier. The advantage of this machine is the lattice-boom.
- A lattice-boom is cable-suspended, and therefore acts as a compression member, not a bending member like the telescoping, hydraulic boom.

LATTICE-BOOM TRUCK CRANES

LATTICE-BOOM TRUCK CRANES

- The lattice-boom structure is of lightweight. The reduction in boom weight means additional lift capacity as the machine predominantly handles hoist load and less weight of boom.
- The lattice-boom does take longer to assemble. The lightweight boom will give a less expensive lattice-boom machine the same hoisting capacity as a larger hydraulic unit.

LATTICE-BOOM TRUCK CRANES

- The disadvantage of these units is the time and effort required disassembling them for transport. In the case of the larger units it may be necessary to remove the entire superstructure. Additionally a second crane is often required for this task. Some newer models are designed so that the machine can separate itself without the aid of another crane.

ROUGH-TERRAIN TRUCK CRANES

- These cranes are mounted on two-axle carriers.
- The operator's cab may be mounted in the upper works allowing the operator to swing with the load.
- On many models the cab is located on the carrier. This is a simpler design because controls do not have to be routed across the turntable. In turn these units have a lower cost.

ROUGH-TERRAIN TRUCK CRANES

- The units are equipped with unusually large wheels in order to improve maneuverability at the job site. Most units can travel on the highway but have maximum speeds of only about 30 mph. In the case of long moves between projects they should be transported on low-bed trailers.

ROUGH-TERRAIN TRUCK CRANES

- Many units now have joy stick controls. A joy stick allows the operator to manipulate four functions simultaneously.
- The most common models are in the 18-50-ton capacity range and typically are employed as utility machines. They are primarily lift machines but are capable of light, intermittent duty-cycle work.

ALL-TERRAIN TRUCK CRANES

- The all-terrain crane is designed with an undercarriage that is capable of long-distance highway travel.
- All-terrain truck carrier has four wheel-drive and four wheel-steer, large tires, and high ground clearance .

ALL-TERRAIN TRUCK CRANES

- They have dual cabs, a lower cab for fast highway travel, and a superstructure cab which has both drive and crane controls.
- The machine can be used for limited pick-and-carry work.

ALL-TERRAIN TRUCK CRANES

- By combining job-site mobility and transit capability, these machines are very good when multiple lifts are required at scattered project sites or at multiple work locations on a single project.

ALL-TERRAIN TRUCK CRANES

- Because all-terrain truck is a combination of two features it has a higher cost than an equivalent capacity hydraulic truck crane or a rough-terrain crane.

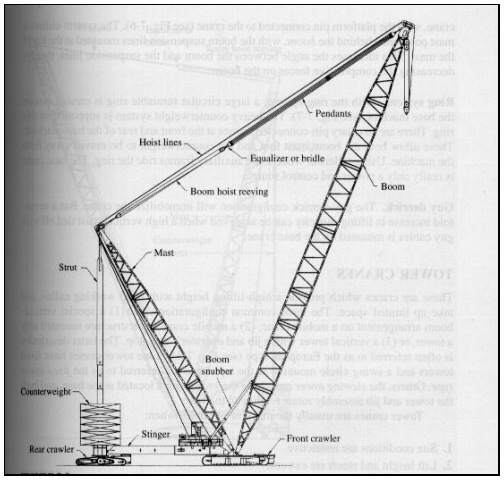
HEAVY LIFT CRANES

- Heavy lift cranes are machines that provide lift capacities in the 600 through 2,000 short-ton range.
- Heavy lift cranes consist of a boom and counterweight each mounted on independent crawlers that are coupled by a stinger. This configuration utilizes a vertical strut and inclined mast to decrease compressive forces in the boom.

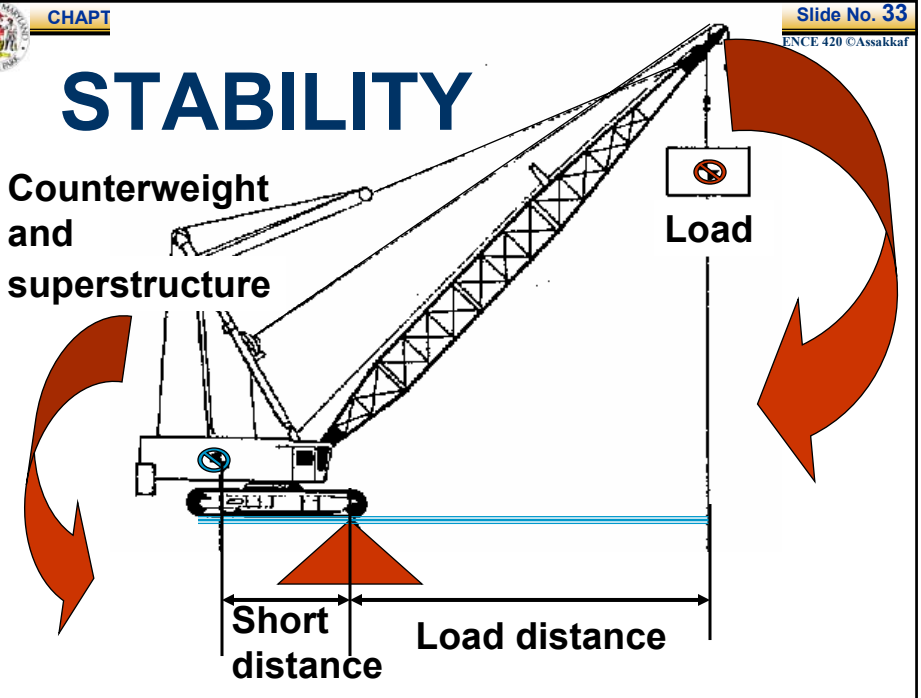
HEAVY LIFT CRANES

HEAVY LIFT CRANES

Components of Heavy Lift Crane



STABILITY



TOWER CRANES

These are cranes that provide a high-lifting height with good working radius, and take up limited space.

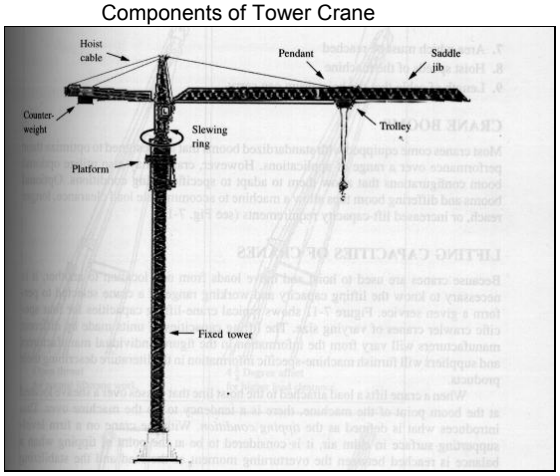
TOWER CRANES

- The three common configurations are:
  - (1) a special vertical boom arrangement on a mobile crane,
  - (2) a mobile crane superstructure mounted atop a tower, or
  - (3) a vertical tower (European type) with a jib and operator's cab atop.

TOWER CRANES

TOWER CRANES

Components of Tower Crane



TOWER CRANES

- Some tower cranes have fixed towers and a swing circle mounted at the top; these are referred to as the fixed tower type.
- Others, the slewing tower type have the swing circle located at the base, and both the tower and jib assembly rotate relative to the base.

TOWER CRANES

- Tower cranes are usually the machines of choice when:
  1. Site conditions are restrictive.
  2. Lift height and reach are extreme.
  3. There is no need for mobility.

SUITABILITY

BUILDING PROJECTS:

- Low rise structures - short cycle times
- High rise structures - long cycle times
- High speed/high volume operations (concrete placement)
- Site conditions (position, locations)
- Vertical reach requirements

SUITABILITY

INDUSTRIAL PROJECTS:

- Very precise (one time hoists)
- Heavy loads (possibly dual hoists)
- Working around fixed objects
- Site conditions (position, locations)
- Vertical reach requirements

SUITABILITY

HEAVY PROJECTS:

- Very precise (one time hoists)
- Heavy loads (possibly dual hoists)
- High speed/high volume operations (concrete placement)
- Multiple work locations
- Site conditions (position, locations)
- Vertical reach requirements

SUITABILITY

HEAVY PROJECTS:

- Heavy loads (possibly dual hoists)

SAFETY

- Crane *fatality* data:
  - Energized power lines 50%
  - Overturning 19%
  - Load dropped 14%
  - Boom collapsed 12%
  - Two-block 5%

SAFETY

- Crane *Accidents*: :
  - Overturning 61.0%
  - Overload 12.5%
  - Rigging 12.5%
  - Road accidents 10.0%

Crane Accidents:

- Overturning 61.0%

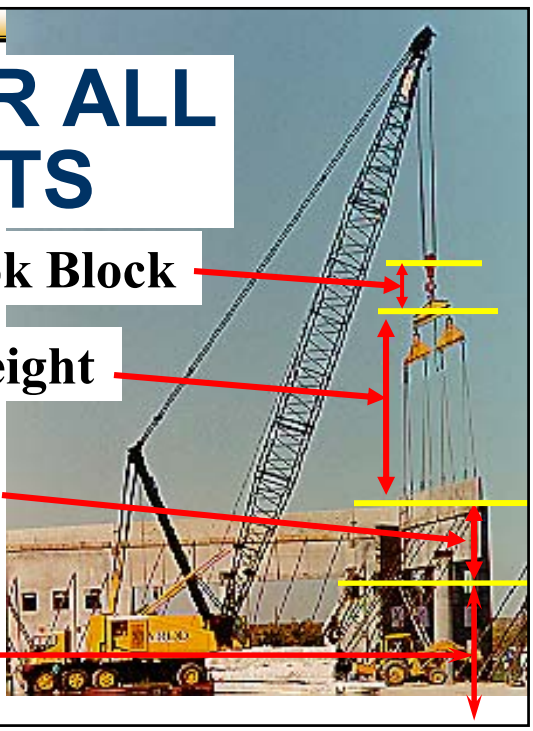
SELECTION FACTORS

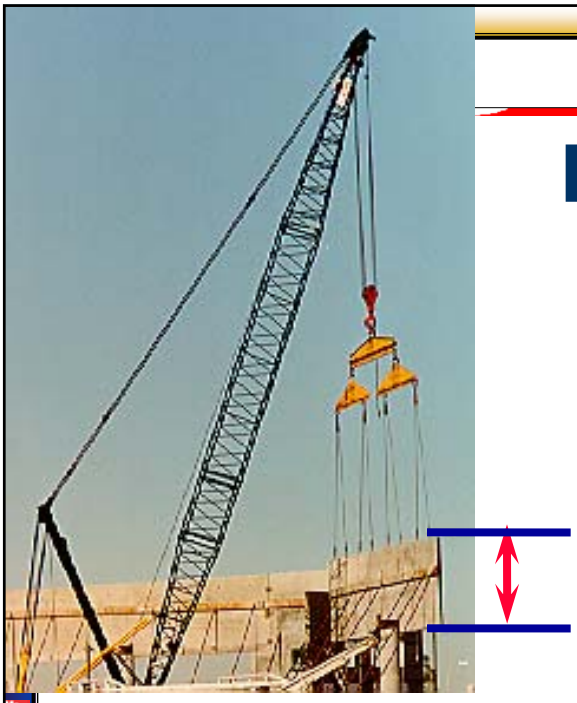
- Height of reach required
- Working envelope
- Maximum load
- Time
- Duty cycle

HEIGHT OF REACH REQUIRED

- ✓ Height load is to be lifted
- ✓ Height of the load
- ✓ Sling height
- ✓ Hook block height
- ✓ Size of the load

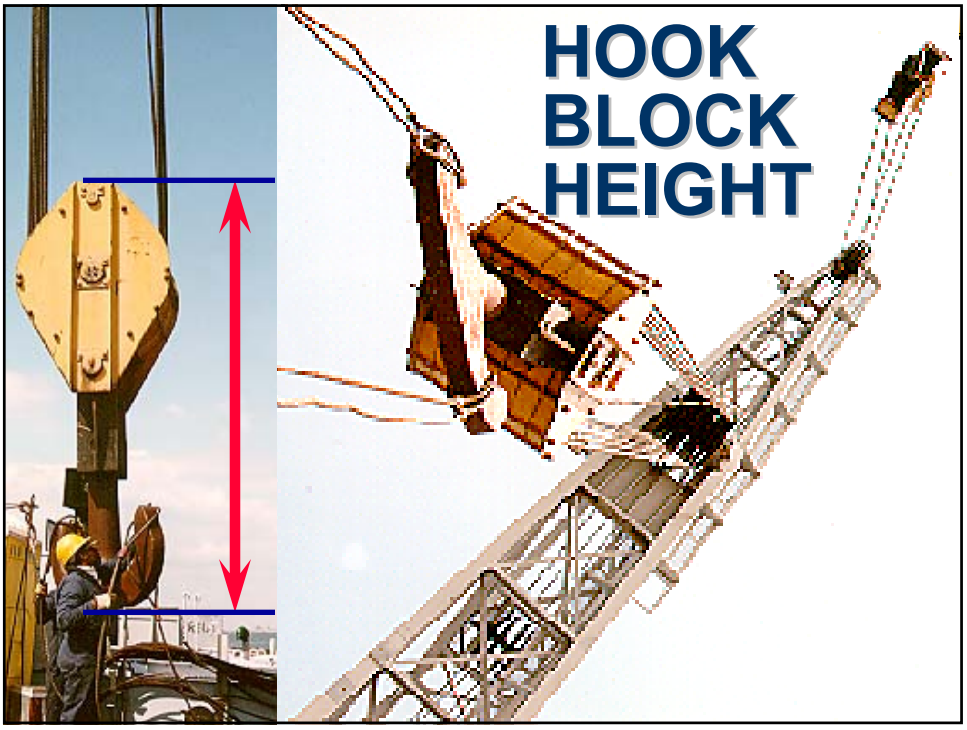
CONSIDER ALL HEIGHTS





HEIGHT OF LOAD

SLING HEIGHT



SIZE OF THE LOAD

RATED LOADS

- The rated load for a crane as published by the manufacturer is based on ideal conditions.
- A partial safety factor in respect to tipping is introduced by the Power Crane and Shovel Association (PCSA) rating standards, which state that the rated load of a lifting crane shall not exceed the following percentages of tipping loads at specified radii.
  1. Crawler-mounted machines, 75%
  2. Rubber-tire-mounted machines 85%
  3. Machines on outriggers, 85%

RATED LOADS

- In addition to PCSA there are other groups that recommend rating criteria. The Construction Safety Association of Ontario recommends that for rubber-tire-mounted machines, on rubber a factor of 0.75 should be utilized.

RATED LOADS

- Load capacity will vary depending on the quadrant position of the boom with respect to the machine's undercarriage.
- In the case of crawler cranes the three quadrants which should be considered are:
  1. Over the side
  2. Over the drive end of the tracks
  3. Over the idler end of the tracks

RATED LOADS

- Crawler-crane quadrants are usually defined by the longitudinal centerline of the machine's crawlers. The area between the centerlines of the two crawlers is considered over the end and the area outside the crawler centerlines is considered over the side.

RATED LOADS

- In the case of wheel mounted cranes the quadrants of consideration will vary with the configuration of the outrigger locations. If a machine has only four outriggers, two on each side, one located forward and one to the rear, the quadrants are usually defined by imaginary lines running from the superstructure center of rotation through the position of the outrigger support. In such a case the three quadrants to consider are:
  1. Over the side
  2. Over the rear (of the carrier)
  3. Over the front (of the carrier)

RATED LOADS

DRAGLINE, CLAMSHELL, MAGNET CRANES

* Large brakes,/clutches for continuous operation
* Patented thermal cooling rings on brakes/clutches for smooth duty-cycle performance
* Heavy-duty, quality-built machinery deck and travel machinery
* Simple, accessible, serviceable

MODEL	CLAMSHELL		DRAGLINE		MAGNET CRANE	
	MAXIMUM		MAXIMUM		MAXIMUM	
	RATING	BOOM	RATING	BOOM	RATING	BOOM
5220	16,000 lb	110 ft	14,000 lb	70 ft	16,000 lb	70 ft
7225	22,750 lb	120 ft	19,500 lb	80 ft	20,700 lb	80 ft
9225	30,000 lb	140 ft	30,000 lb	100 ft	30,000 lb	100 ft
12220	75,000 lb	200 ft	55,000 lb	160 ft	75,000 lb	160 ft
METRIC						
5220	7,250 kg	33.5 m	6,350 kg lb	21.3 m	7,258 kg	21.3 m
7225	10,319 kg	36.5 m	8,845 kg lb	24.3 m	9,390 kg	24.3 m
9225	13,610 kg	42.6 m	13,610 kg lb	30.4 m	13,610 kg	30.4 m
12220	34,020 kg	60.9 m	24,948 kg lb	48.7 m	34,020 kg	48.7 m

NOTE: Refer to specifications for boom length and capacity combination

Example 1

Can the tower crane, whose load chart is given in Table 1(Table 14.3 of Textbook), lift a 15,000-lb load at a radius of 142 ft? The crane has a L7 jib and a two-part line hoist. The slings that will be used for the pick weigh 400 lb. Assume 5% margin be applied to computed weight.

Weight of Load = 15,000 lb

Weight of slings = 400 lb

Total Weight = 15,000 + 400 = 15,400 lb

Required Capacity = 15,400 X 1.05 = 16,170 lb

From Table 1, the maximum capacity at a 142-ft radius is 16,400 lb

16,400 lb > 16,170 lb

Therefore, the crane can safely make the lift

Example 1 (cont'd)

Table 1. (Text 14.3) Lifting Capacities (lb) for a Tower Crane

Lifting capacities, in pounds, for a tower crane

Jib model	L1	L2	L3	L4	L5	L6	L7	Hook reach
Maximum hook reach	104'-0"	123'-0"	142'-0"	161'-0"	180'-0"	199'-0"	218'-0"	
Lifting capacities in pounds, two-part line	27,600	27,600	27,600	27,600	27,600	27,600	27,600	10'-3"
	27,600	27,600	27,600	27,600	27,600	27,600	27,600	88'-2"
	27,600	27,600	27,600	27,600	27,600	27,600	25,800	94'-6"
	27,600	27,600	27,600	27,600	27,600	25,800	24,200	101'-0"
	27,600	27,600	27,600	27,600	26,800	24,900	23,400	104'-0"
		27,600	27,600	27,600	25,200	23,600	22,200	109'-8"
		27,600	27,600	25,600	23,300	21,800	20,500	117'-8"
		27,000	27,000	25,100	22,800	21,300	20,100	120'-0"
		26,300	26,300	24,300	22,200	20,700	19,500	123'-0"
			24,800	22,800	20,800	19,300	18,300	130'-0"
			22,400	20,700	18,700	17,400	16,400	142'-0"
				19,500	17,600	16,300	15,400	150'-0"
				18,800	16,800	15,700	14,800	155'-0"
				17,900	16,200	15,100	14,200	161'-0"
				-	15,200	14,200	13,300	170'-0"
					14,200	13,200	12,400	180'-0"
						12,300	11,600	190'-0"
						11,700	10,800	199'-0"
							10,200	210'-0"
							9,700	218'-0"

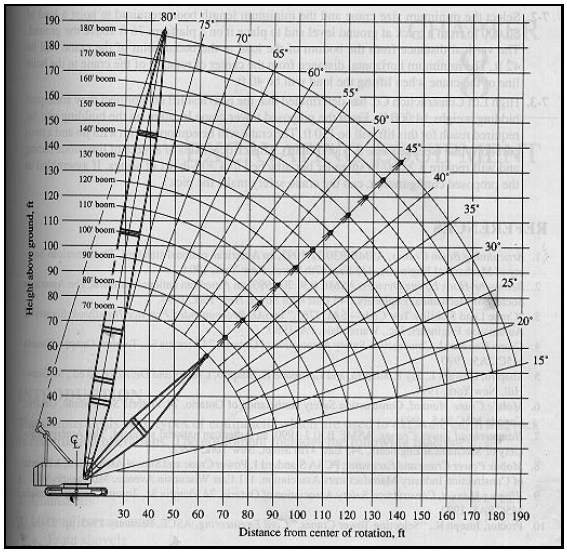
Example 2

Determine the minimum boom length that will permit the crawler crane to lift a load which is 34 ft high to a position 114 ft above the surface on which the crane is operating. The length of the block, hook, and slings that are required to attach the hoist rope to the load is 26 ft. The location of the project will require the crane to pick up the load from a truck at a distance of 70 ft from the center of rotation of the crane. If the block, hook, and slings weigh 5,000 lb, determine the maximum net weight of the load that can be hoisted.

The operating radius = 70 ft
Total height of boom point = 114 + 34 + 26 = 174 ft
From Figure 1 (Figure 14.11 of Textbook), for a radius of 70 ft, the height of of the boom point is 178 ft for 180-ft boom, which is high enough.
From Table 2 (Table 14.1 in Textbook),
for 180-ft boom and 70-ft radius, Maximum total load = 47,600 lb
Hence
Maximum Safe Weight = 47,600 - 5,000 = 42,600 lb

Example 2 (cont'd)

Figure 1. (Text 14.11) Working Ranges for a 200-ton Crawler Crane (Manitowoc Eng. Co)



Example 2 (cont'd)

Table 2. (Text 14.1) Lifting Capacities (lb) for 200-ton Crawler Crane with 180 ft of Boom

Radius (ft)	Capacity (lb)	Radius (ft)	Capacity (lb)	Radius (ft)	Capacity (lb)
32	146,300	80	39,200	130	17,900
36	122,900	85	35,800	135	16,700
40	105,500	90	32,800	140	15,500
45	89,200	95	30,200	145	14,500
50	76,900	100	27,900	150	13,600
55	67,200	105	25,800	155	12,700
60	59,400	110	23,900	160	11,800
65	53,000	115	22,200	165	11,100
70	47,600	120	20,600	170	10,300
75	43,100	125	19,200	175	9,600

† Specified capacities based on 75% of tipping loads.
Source: Manitowoc Engineering Co.