CHAPTER

Construction Planning, Equipment, and Methods

Sixth Edition

DRAGLINES AND CLAMSHELLS

A. J. Clark School of Engineering •Department of Civil and Environmental Engineering

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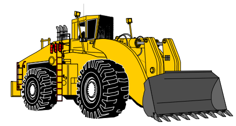

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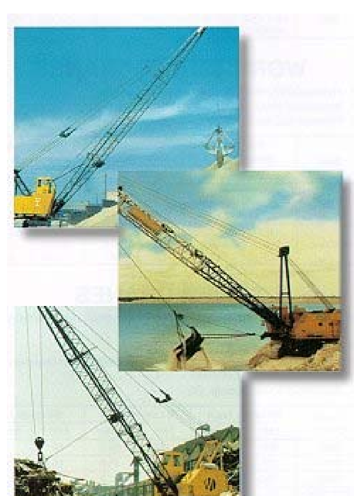
DRAGLINE, CLAMSHELL AND MAGNET CRANES



DRAGLINES AND CLAMSHELLS

DRAGLINES AND CLAMSHELLS							
		Maximum Cap.(lbs.)			Weights (lbs.)	
	Model	Drag	Clam	Boom Lengths	Drag	Clam
EPIC	777	20,000	29,500	60' - 120' (2)	--------	--------
EPIC	888	20,000	30,000	70' - 120'	--------	--------
EPIC	M-250	---------	30,000	70' - 140' (1)	--------	387,035
VICON	3900	20,000	28,000	60' - 120' (2)	198,505	198,070
VICON	3900W S-2	20,000	28,000	60' - 120' (2)	220,660	219,850
VICON	3950W	20,000	32,000 (3)	70' - 120'	232,700	232,700
VICON	3950D	30,000	32,000	70' - 120'	282,430	282,430
VICON	4100W	30,000	32,000 (3)	70' - 120'	335,195	334,735
VICON	4600 S-1	42,000	36,000	100' - 140'	420,985	429,660
VICON	4600 S-3	42,000	50,000	80' - 140'	487,220	482,145
VICON	4600 S-4	--------	50,000	80' - 160'	---------	547,505
(1) Lengths over 120' require optional front drum. (2) 120' clam, 100' drag						
(3) With full-width tandem drums						

DRAGLINES

- Draglines are used to excavate material and to load it into hauling units, such as trucks or tractor-pulled wagons, or to deposit it in levees, dams, and spoil banks near the pits from which it is excavated.

DRAGLINES

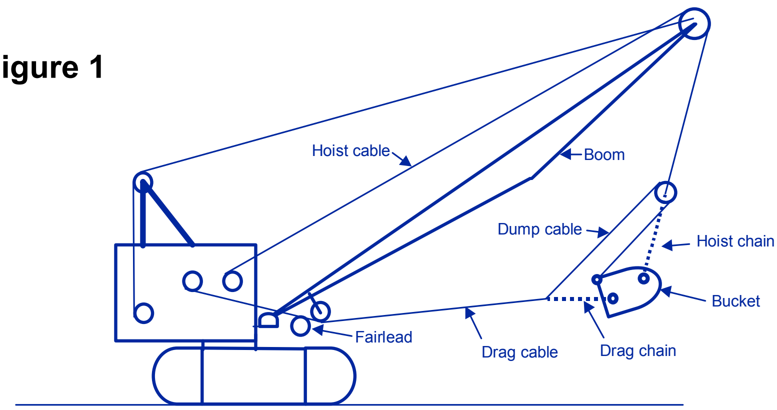
- The dragline is designed to excavate below the level of the machine.
- A dragline usually does not have to go into a pit or hole in order to excavate. It operates adjacent to the pit while excavating material from the pit by casting its bucket. This is very advantageous when earth is removed from a ditch, canal, or pit containing water.

DRAGLINES

- Frequently, it is possible to use a dragline with a long boom to dispose of the earth in one operation if the material can be deposited along the canal or near the pit. This eliminates the need for hauling units, thus reducing the cost of handling the material.

BASIC COMPONENTS OF DRAGLINE

Figure 1



TYPES OF DRAGLINES

- Draglines may be divided into three types:
  1. Crawler-mounted
  2. Wheel-mounted, self-propelled
  3. Truck-mounted

TYPES OF DRAGLINES

- *Crawler-mounted* draglines can operate over soft ground conditions that would not support wheel-or truck-mounted equipment.
- The travel speed of a crawler machine is very slow, frequently less than 1 mph, and it is necessary to use auxiliary, hauling equipment to transport the unit from one job to another.

TYPES OF DRAGLINES

- ***Wheel-and track-mounted*** units may have travel speeds in excess of 30 mph.

THE SIZE OF A DRAGLINE

- The size of a dragline is indicated by the size of the bucket, expressed in cubic yards (cu yd).
- Most draglines may handle more than one size bucket, depending on the length of the boom utilized and the class and weight of the material excavated.

THE SIZE OF A DRAGLINE

- Since the maximum lifting capacity of a dragline is limited by the force which will tilt the machine over, it is necessary to reduce the size of the bucket when a long boom is used or when the excavated material has a high unit weight.

THE SIZE OF A DRAGLINE

- In practice, the combined weight of the bucket and its load should produce a tilting force that is not greater than 75% of the force required to tilt the machine.

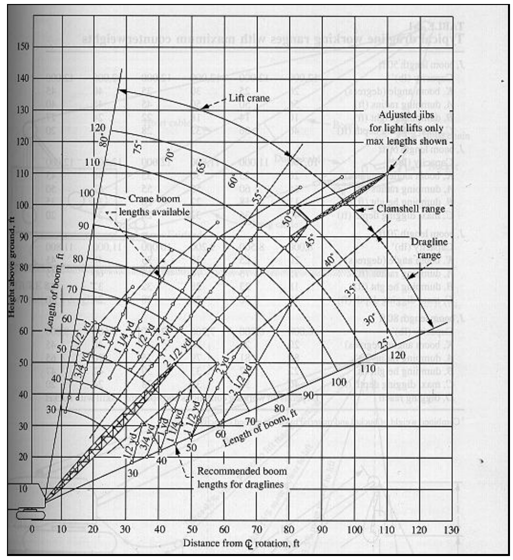
THE SIZE OF A DRAGLINE

- A longer boom, with a smaller bucket, will be used to increase the digging reach or the dumping radius when it is not desirable to bring in a larger machine.
- If the material is difficult to excavate, the use of a smaller bucket, which will reduce the digging resistance, may permit an increase in production.

THE SIZE OF A DRAGLINE

Figure 2

Relationship between bucket size and boom length and angle



THE SIZE

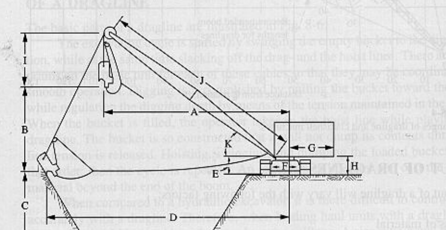
Figure 3

Typical Dragline Working Ranges with Maximum Weight

Typical dragline working ranges with maximum counterweights

J, boom length 50 ft						
Capacity (lb)†	12,000	12,000	12,000	12,000	12,000	12,000
K, boom angle (degrees)	20	25	30	35	40	45
A, dumping radius (ft)	55	50	50	45	45	40
B, dumping height (ft)	10	14	18	22	24	27
C, max. digging depth (ft)	40	36	32	28	24	20
J, boom length 60 ft						
Capacity (lb)†	10,500	11,000	11,800	12,000	12,000	12,000
K, boom angle (degrees)	20	25	30	35	40	45
A, dumping radius (ft)	65	60	55	55	52	50
B, dumping height (ft)	13	18	22	26	31	35
C, max. digging depth (ft)	40	36	32	28	24	20
J, boom length 70 ft						
Capacity (lb)†	8,000	8,500	9,200	10,000	11,000	11,800
K, boom angle (degrees)	20	25	30	35	40	45
A, dumping radius (ft)	75	73	70	65	60	55
B, dumping height (ft)	18	23	28	32	37	42
C, max. digging depth (ft)	40	36	32	28	24	20
J, boom length 80 ft						
Capacity (lb)†	6,000	6,700	7,200	7,900	8,600	9,800
K, boom angle (degrees)	20	25	30	35	40	45
A, dumping radius (ft)	86	81	79	75	70	65
B, dumping height (ft)	22	27	33	39	42	47
C, max. digging depth (ft)	40	36	32	28	24	20
D, digging reach	Depends on working conditions and operator's skill with bucket					

†Combined weight of bucket and material must not exceed capacity.



OPERATION OF A DRAGLINE

- The excavating cycle is started by swinging the empty bucket to the digging position, while at the same time slacking off the drag-and the hoist lines.
- There are separate drums on the basic unit for each of these cables so that they may be coordinated into a smooth operation.

OPERATION OF A DRAGLINE

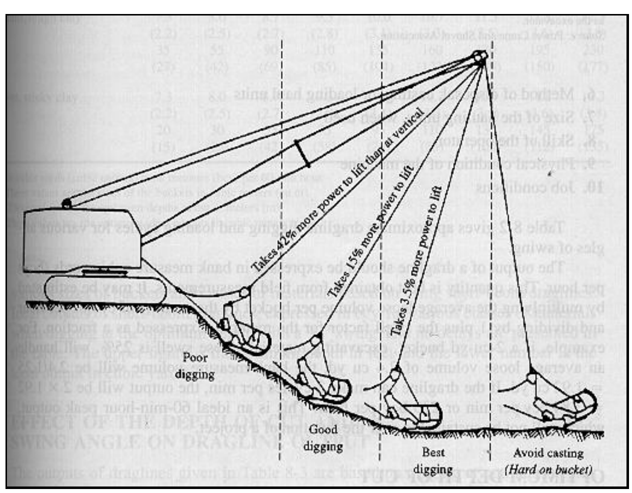
- Digging is accomplished by pulling the bucket toward the machine while regulating the digging depth by means of the tension maintained in the hoist line.
- When the bucket is filled, the operator takes in the hoist line while playing out the dragline.

OPERATION OF A DRAGLINE

- The bucket is so constructed that it will not dump its contents until the drag line tension is released.
- Hoisting, swinging, and dumping the loaded bucket follow in that order; then the cycle is repeated.
- An experienced operator can cast the excavated material beyond the end of the boom.

OPERATION OF A DRAGLINE

Figure 4
Dragline Digging Zones



OUTPUT OF DRAGLINES

- The output of a dragline will vary with the following factors:
    1. Class of material
    2. Depth of cut
    3. Angle of swing
    4. Size and type of bucket
    5. Length of boom
    6. Method of disposal, casting, or loading haul units
    7. Size of the hauling units, when used
    8. Skill of the operator
    9. Physical condition of the machine
    10. Job conditions

OUTPUT OF DRAGLINES

- The output of a dragline should be expressed in bank measure cubic yards (bcy) per hour. This quantity is best obtained from field measurements. It may be estimated by multiplying the average loose volume per bucket by the number of cycles per hour and dividing by 1 plus the swell factor for the material, expressed as a fraction.

OUTPUT OF DRAGLINES

Example:

If a 2-cu-yd bucket, excavating material whose swell is 25%, will handle an average loose volume of 2.4 cu yd, the bank-measure volume will be

$$2.4/1.25 = 1.92 \text{ cu yd.}$$

If the dragline can make 2 cycles per min, the output will be

$$2 \times 1.92 = 3.84 \text{ bcy per min or } 230 \text{ bcy per hour.}$$

OUTPUT OF DRAGLINES

Table 1. **Approximate Dragline Digging and Loading Cycles for Various Angles of Swing**

Approximate dragline digging and loading cycles for various angles of swing†

Size of drag-line bucket (cu yd)	Easy digging light moist clay or loam angle of swing (degrees)				Sand or gravel angle of swing (degrees)				Good common earth angle of swing (degrees)			
	45	90	135	180	45	90	135	180	45	90	135	180
$\frac{3}{8}$	16	19	22	25	17	20	24	27	20	24	28	31
$\frac{1}{2}$	16	19	22	25	17	20	24	27	20	24	28	31
$\frac{3}{4}$	17	20	24	27	18	22	26	29	21	26	30	33
1	19	22	26	29	20	24	28	31	23	28	33	36
$1\frac{1}{4}$	19	23	27	30	20	25	29	32	23	28	33	36
$1\frac{1}{2}$	21	25	29	32	22	27	31	34	25	30	35	38
$1\frac{3}{4}$	22	26	30	33	23	28	32	35	26	31	36	39
2	23	27	31	35	24	29	33	37	27	32	37	41
$2\frac{1}{2}$	25	29	34	38	26	31	36	40	29	34	40	44

† Time is in seconds with no delays when digging at optimum depths of cut and loading trucks on the same grade as the excavator.

Source: Power Crane and Shovel Association.

OPTIMUM DEPTH OF CUT

- Greatest output of a dragline is expected when it is operating at the optimum depth of cut
- The following Table (Table 2, or Table 18-3 of Textbook) provides the optimum depth of cut for various sizes of buckets and types of materials based on using short-boom draglines.

OPTIMUM DEPTH OF CUT

Table 2. **Optimum Depth of Cut and Ideal Outputs of Short-boom Draglines**

TABLE 8-3
Optimum depth of cut and ideal outputs of short-boom draglines[†]

Class of material	Size of bucket [cu yd (cu m)][‡]								
	$\frac{3}{8}$ (0.29)[‡]	$\frac{1}{2}$ (0.38)[‡]	$\frac{3}{4}$ (0.57)[‡]	1 (0.76)[‡]	$1\frac{1}{4}$ (0.95)[‡]	$1\frac{1}{2}$ (1.14)[‡]	$1\frac{3}{4}$ (1.33)[‡]	2 (1.53)[‡]	$2\frac{1}{2}$ (1.91)[‡]
Moist loam or light sandy clay	5.0 (1.5)[§] 70 (53)[¶]	5.5 (1.7)[§] 95 (72)[¶]	6.0 (1.8)[§] 130 (99)[¶]	6.6 (2.0)[§] 160 (122)[¶]	7.0 (2.1)[§] 195 (149)[¶]	7.4 (2.2)[§] 220 (168)[¶]	7.7 (2.4)[§] 245 (187)[¶]	8.0 (2.5)[§] 265 (202)[¶]	8.5 (2.6)[§] 305 (233)[¶]
Sand and gravel	5.0 (1.5) 65 (49)	5.5 (1.7) 90 (69)	6.0 (1.8) 125 (95)	6.6 (2.0) 155 (118)	7.0 (2.1) 185 (141)	7.4 (2.2) 210 (160)	7.7 (2.4) 235 (180)	8.0 (2.5) 255 (195)	8.5 (2.6) 295 (225)
Good common earth	6.0 (1.8) 55 (42)	6.7 (2.0) 75 (57)	7.4 (2.4) 105 (81)	8.0 (2.5) 135 (104)	8.5 (2.6) 165 (127)	9.0 (2.7) 190 (147)	9.5 (2.8) 210 (162)	9.9 (3.0) 230 (177)	10.5 (3.2) 265 (204)
Hard, tough clay	7.3 (2.2) 35 (27)	8.0 (2.5) 55 (42)	8.7 (2.7) 90 (69)	9.3 (2.8) 110 (85)	10.0 (3.1) 135 (104)	10.7 (3.3) 160 (123)	11.3 (3.5) 180 (139)	11.8 (3.6) 195 (150)	12.3 (3.8) 230 (177)
Wet, sticky clay	7.3 (2.2) 20 (15)	8.0 (2.5) 30 (23)	8.7 (2.7) 55 (42)	9.3 (2.8) 75 (58)	10.0 (3.1) 95 (73)	10.7 (3.3) 110 (85)	11.3 (3.5) 130 (100)	11.8 (3.6) 145 (112)	12.3 (3.8) 175 (135)

[†] In cubic yards (cubic meters) bank measure (bcy) per 60-min hour.
[‡] These values are the sizes of the buckets in cubic meters (cu m).
[§] These values are the optimum depths of cut in meters (m).
[¶] These values are the optimum ideal outputs in cubic meters (cu m).

OPTIMUM DEPTH OF CUT

- Ideal outputs (bcy) of short-boom draglines are accomplished when digging at the optimum depth with a 900 swing and no delays are presented in the table.
- The upper figure is the optimum depth in feet and the lower number is the ideal output in *cubic yards*.

EFFECT OF THE DEPTH OF CUT AND SWING ANGLE ON DRAGLINE OUTPUT

- The table (Table 2) also gives the optimum depth and ideal outputs in metric units (e.g., m and m3).
- The outputs of draglines provided in Table 2 (Table 18-3 of Textbook) are based on digging at optimum depths with a swing angle of 90^0.

EFFECT OF THE DEPTH OF CUT AND SWING ANGLE ON DRAGLINE OUTPUT

- For any other depth or swing angle, the ideal output of the machine must be adjusted by an appropriate depth-swing factor.
- The effect of the depth of cut and swing angle on dragline production is given in the following table (Table 3, or Table 18-4 of Textbook).

EFFECT OF THE DEPTH OF CUT AND SWING ANGLE ON DRAGLINE OUTPUT

- The percent of optimum depth of cut in the table is obtained by dividing the actual depth of cut by the optimum depth for the given material and bucket, then multiplying the result by 100.

EFFECT OF THE DEPTH OF CUT AND SWING ANGLE ON DRAGLINE OUTPUT

Table 3. Factors for Depth of Cut and Angle of Swing Effect on Dragline Production (Table 8-4 of Textbook)

Percent of optimum depth	Angle of swing (degrees) 30	45	60	75	90	120	150	180
20	1.06	0.99	0.94	0.90	0.87	0.81	0.75	0.70
40	1.17	1.08	1.02	0.97	0.93	0.85	0.78	0.72
60	1.24	1.13	1.06	1.01	0.97	0.88	0.80	0.74
80	1.29	1.17	1.09	1.04	0.99	0.90	0.82	0.76
100	1.32	1.19	1.11	1.05	1.00	0.91	0.83	0.77
120	1.29	1.17	1.09	1.03	0.98	0.90	0.82	0.76
140	1.25	1.14	1.06	1.00	0.96	0.88	0.81	0.75
160	1.20	1.10	1.02	0.97	0.93	0.85	0.79	0.73
180	1.15	1.05	0.98	0.94	0.90	0.82	0.76	0.71
200	1.10	1.00	0.94	0.90	0.87	0.79	0.73	0.69

Example 1

- A 2-cu-yd short-boom dragline is to be used to excavate hard, tough clay. The depth of cut will be 15.4 ft, and the swing angle will be 120^0. Compute the probable production of the dragline.

Example 1 (cont'd)

Optimum Depth of Cut = 11.8 ft $\Rightarrow$ 195 cu-yd Ideal production (see Table 2)

$$\text{Percent of Optimum Depth} = \frac{15.4}{11.8} \times 100 = 130\%$$

The appropriate depth-swing factor = 0.89 (by interpolation in Table 3)

The Probable Production = 195 (0.89) = 173.6 bcy per 60-min hour

The production should be corrected for normal delays (i,e., 50-min hour)

$$\text{Production (corrected)} = 173.6\left(\frac{50}{60}\right) = 145\,\frac{\text{bcy}}{\text{hr}}$$

EFFECT OF BUCKET SIZE AND BOOM LENGTH ON DRAGLINE PRODUCTION

- For best operating efficiency, one should match the dragline and the bucket properly.
- There are generally three types of buckets
  - ✓ ***Light Duty***, for easily dug material (i.e., sandy loam and sandy clay)
  - ✓ ***Medium Duty***, for general excavation (I.e., clay, soft shale)
  - ✓ ***Heavy Duty***, for mine tripping and handling blasted rocks

EFFECT OF BUCKET SIZE AND BOOM LENGTH ON DRAGLINE PRODUCTION

- Buckets are sometimes are perforated to allow access water to drain.
- In selecting the most suitable size of bucket for use with a given dragline, the loose weight (in lb per cu ft) should be known.

EFFECT OF BUCKET SIZE AND BOOM LENGTH ON DRAGLINE PRODUCTION

- Larger buckets can increase production, but they may exceed the recommended safe load for a dragline.
- The following table (Table 4, or Table 18.5 of Textbook) provides representative capacities, weight, and dimensions for dragline buckets

EFFECT OF BUCKET SIZE AND BOOM LENGTH ON DRAGLINE PRODUCTION

Table 4. Capacities, Weights, and Dimension of Dragline Buckets

Size (cu yd)	Struck capacity (cu ft)	Weight of bucket (lb) Light duty	Medium duty	Heavy duty	Dimension (in.) Length	Width	Height
$\frac{3}{8}$	11	760	880		35	28	20
$\frac{1}{2}$	17	1,275	1,460	2,100	40	36	23
$\frac{3}{4}$	24	1,640	1,850	2,875	45	41	25
1	32	2,220	2,945	3,700	48	45	27
$1\frac{1}{4}$	39	2,410	3,300	4,260	49	45	31
$1\frac{1}{2}$	47	3,010	3,750	4,525	53	48	32
$1\frac{3}{4}$	53	3,375	4,030	4,800	54	48	36
2	60	3,925	4,825	5,400	54	51	38
$2\frac{1}{4}$	67	4,100	5,350	6,250	56	53	39
$2\frac{1}{2}$	74	4,310	5,675	6,540	61	53	40
$2\frac{3}{4}$	82	4,950	6,225	7,390	63	55	41
3	90	5,560	6,660	7,920	65	55	43

Example 2

The material to be handled has a loose weight of 90 lb per cu ft. The use of a 2-cu-yd medium duty bucket will be considered. The dragline is to be operated with an 80-ft boom at a 40^0 angle. Is the 2-cu-yd considered safe for the job? If not, what size bucket should be used.

Weight of Bucket = 4,825 lb (from Table 4)
Weight of Material = 60 X 90 = 5,400 lb (60 cu ft from Table 4)

Combined Weight = 10,225 lb

For 80-ft boom at a 40^0 swing angle:
Maximum Safe Load = 8,600 lb (from Figure 3)

Combined Weight (10,225 lb) > Maximum Safe Load (8600 lb) NOT OK

Example 2 (cont'd)

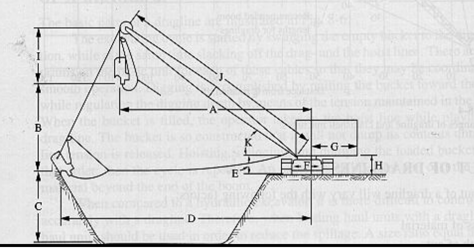
Figure 3

Typical Dragline Working Ranges with Maximum Weight

Typical dragline working ranges with maximum counterweights

J, boom length 50 ft						
Capacity (lb)†	12,000	12,000	12,000	12,000	12,000	12,000
K, boom angle (degrees)	20	25	30	35	40	45
A, dumping radius (ft)	55	50	50	45	45	40
B, dumping height (ft)	10	14	18	22	24	27
C, max. digging depth (ft)	40	36	32	28	24	20
J, boom length 60 ft						
Capacity (lb)†	10,500	11,000	11,800	12,000	12,000	12,000
K, boom angle (degrees)	20	25	30	35	40	45
A, dumping radius (ft)	65	60	55	55	52	50
B, dumping height (ft)	13	18	22	26	31	35
C, max. digging depth (ft)	40	36	32	28	24	20
J, boom length 70 ft						
Capacity (lb)†	8,000	8,500	9,200	10,000	11,000	11,800
K, boom angle (degrees)	20	25	30	35	40	45
A, dumping radius (ft)	75	73	70	65	60	55
B, dumping height (ft)	18	23	28	32	37	42
C, max. digging depth (ft)	40	36	32	28	24	20
J, boom length 80 ft						
Capacity (lb)†	6,000	6,700	7,200	7,900	8,600	9,800
K, boom angle (degrees)	20	25	30	35	40	45
A, dumping radius (ft)	86	81	79	75	70	65
B, dumping height (ft)	22	27	33	39	42	47
C, max. digging depth (ft)	40	36	32	28	24	20
D, digging reach	Depends on working conditions and operator's skill with bucket					

†Combined weight of bucket and material must not exceed capacity.



NOTE: Figure 3 is repeated here for Example 2

Example 2 (cont'd)

Try a 1½-cu-yd bucket
Weight of Bucket = 3,750 lb (from Table 4)
Weight of Material = 47 X 90 = 4,230 lb (47 cu ft from Table 4)

Combined Weight = 7,980 lb

For 80-ft boom at a 40^0 swing angle:
Maximum Safe Load = 8,600 lb (from Figure 3)

Combined Weight (7,980 lb) < Maximum Safe Load (8600 lb) OK

Hence, use 1½-cu-yd bucket

CLAMSHELLS

Clamshells are used to handle loose material such as sand, gravel, and crushed stone. They are specially suited for lifting material vertically.

CLAMSHELLS

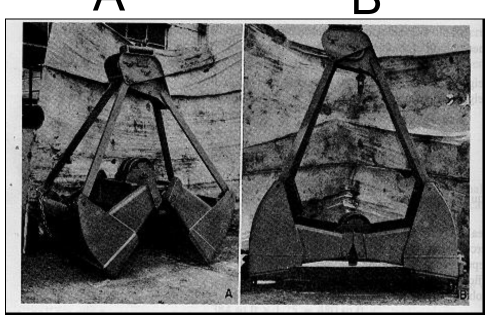
- Clamshell buckets are available in various sizes, and in heavy-duty types for digging, medium-weight types for general-purpose work and lightweight types for rehandling light materials.

CLAMSHELLS

- Manufacturers supply buckets either with removable teeth or without teeth.
- Teeth are used in digging the harder types of materials but are not required when a bucket is used for re-handling purposes.

CLAMSHELLS

A B



(A) Wide Re-handling Clamshell bucket
(B) Heavy Duty Clamshell Bucket

CAPACITY OF CLAMSHELL BUCKETS

- The capacity of a clamshell bucket is usually given in cubic yards.
- A more accurate capacity is given as water level, plate-line, or heaped-measure, generally expressed in cubic feet.

CAPACITY OF CLAMSHELL BUCKETS

- The water-level capacity is the capacity of the bucket if it were hung level and filled with water.
- The plate-line capacity indicates the capacity of the bucket following a line along the tops of the clams.

CAPACITY OF CLAMSHELL BUCKETS

- The heaped capacity is the capacity of the bucket when it is filled to the maximum angle of repose for the given material.
- In specifying the heaped capacity, the angle of repose is usually 45º.

PRODUCTION RATES FOR CLAMSHELLS

- Because of the variable factors which affect the operations of a clamshell, it is difficult to give dependable production rates.

PRODUCTION RATES FOR CLAMSHELLS

- The variable factors affecting operations include:
  - ✓The difficulty of loading the bucket,
  - ✓The size load obtainable,
  - ✓The height of lift,
  - ✓The angle of swing,
  - ✓The method of disposing of the load, and
  - ✓The experience of the operator.