ENGINEERING MECHANICS

Notes by-

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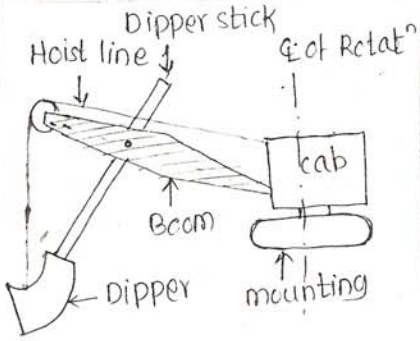
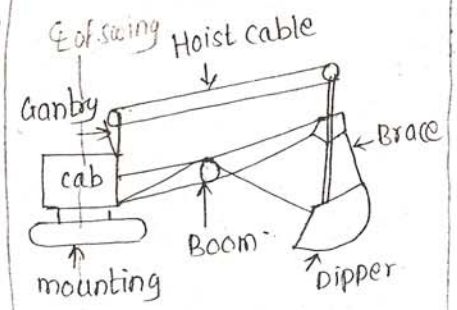
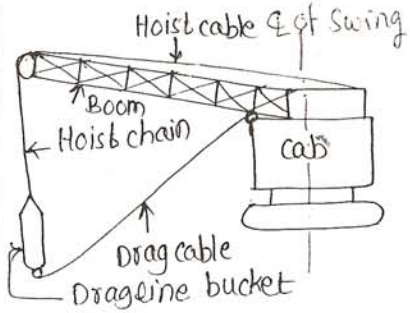
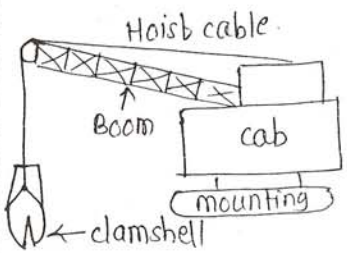
Comparism of family of const° Equipment

Point	Dipper / Power shovel	Backhol / Drag shovel / back shovel	Dragline	clampshell
Figure Er. Pravin Kolhe (M.E Civil)				
components: common are:- 1] Mounting 2] cab 3] Boom. 4] Hoist cable.	① Dipper ② Dipper stick.	① Dipper ② Brace ③ Ganby	① Dragline ② Dragline bucket ③ Hoist chain	① clamshell
Suitability	① Digging hard soil, rock, ② sides of roads, overburdon	① Digging trench, pit ② Basement	① Remove earth from canal ditch, pit etc.	① Lifting vertically.
Digging level-	above footing level.	Below footing level.	Below footing level.	below footing level.
Cycle Time	Less	Moderate	More	Highest
Digging hard soil or rock	Good	Good	Bad	Poor
Digging wet soil.	Poor	Poor	Good	Good.
output $\propto \frac{1}{\text{cycle Time}}$	High	moderate.	less	less.

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Classification of Equipments

① Excavating & Transporting Equipments

a] Tractor
- Crawler Tractor
- wheel Tractor
  - 2 wheel
  - 4 wheel

b] Bulldozer
- Bulldozer
- Angledozer
- cable controlled
- Hydraulic control
- Crawler mounted
- wheel mounted

c] Power shovel
- Crawler mounted
- wheel mounted

d] Drag line

e] clam sheet
- Light bucket
- Heavy Bucket

f] Scraper
- Crawler mounted
- wheel mounted

g] hoe/ backhoe/ Back shovel /Pull shovel

h] Trenchers
- wheel trencher
- ladder trencher

② Hauling & conveying Equipments

a] On-Highway

b] OFF highway
- Rigid frame Dump Trucks (RDT)
- Articulated Dump Trucks (ADT)

c] conveying equipment :- Belt conveyor

③ Drilling equipment –

a] Percussion drills
- Jack hammer or sinker
- Drifter
- wagon drill
- Track mounted drill
- churn drill
- Piston drill

b] Abrasion drill
- Blast hole drill
- shot drill
- Diamond drill.

c] Fusion piercing drill -

④ Crushing equipments –

a] Primary crusher
- Jaw crusher
- Gyratory crusher
- Hammer mill

b] secondary crusher
- cone crusher
- Roll crusher
- Hammer mill

c] Tertiary crusher
- Roll crusher
- Rod mill
- Ball mill

⑤ screening
- Revolving
- shaking
- Vibrating

⑥ Foundation grouting
- Grouts →
  - cement & water
  - cement, rock flour & water
  - cement, clay & water
  - cement, clay, sand & water
  - Asphalt
  - chemical.

⑦ Dewatering & ~~Pumping~~ equipment -
- Mtds →
  - sump & ditches
  - sheeting & open pumping
  - Deep well sumps
  - well point system
  - Deep well drainage
  - Horizontal drainage
  - Vaccum dewatering
  - Electro-osmosis.

⑧ Pumping equipment
- a] Displacement Type →
  - Reciprocating Pump
  - Diphragm pump.
- b] centrifugal pump →
  - Conventional
  - self-priming
  - Air-operated

⑨ concrete mixer →
- Tilting
- Non-Tilting

⑩ concrete compaction :-
- Mtds: a] Mannual → Tamping rod
- b] Mechanical (using vibrator) →
  - Internal (Needle) Vibrator
  - External (Form) Vibrator
  - Surface (screed) Vibrator
  - Vibrating Table
- c] special →
  - vibroprocessing
  - shock
  - centrifugation
  - Airjets.

⑪ Hoisting Equipments :-
- a] pulley
- b] chain hoist
- c] Jacks
- d] winch
- e] Cranes →
  - Derrick
  - Mobile
  - Whirler
  - Tower
  - Hydraulic
  - Gantry

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CONSTRUCTION EQUIPMENTS

MPSC - Questions :-

(5) (3) Diff (9) (1) O/P of power shovel - 8 factors affecting o/p (fig, parts)
(4) (2) (2) Dragline - sketch, component, operat^n, use
(3) Use & sketch - Clamshell Bucket, Whirler Crane, Travelling gantries
(4) Compare diff members of family of const^n equipments
(5) Compare gasoline & diesel
(6) shovel / hoe - comparism
(7) o/p of conveyor belt.
(8) Tipper - sketch, f^n
(9) stone crusher - Reduct^n ratio, fig - Jaw crusher.
(10) Tilting mixer - Rating, excess Qty. permitted, mixing time, out of one shift of 8hr.
(11) Vibrator
(12) Necessity of lubricants
(13) Air compressor.
(13) o/p of excavators.
(15) dumper - classificat^n factor, size & No of dumper reqd.
(16) compacting eq^n - FOS.
(17) Sheep foot roller - working
(15) Types of crusher, FOS - c
(19) classif^n of Cranes - Use & method.
(20) Basic shovel
(22) compare tilting & non tilting mixer. Rating of mixer.
(23) Truck mixer, concrete vibrator.
(2) (24) Belt conveyor - sketch.
(25) cableway, ropeway
(26) classif^n of earth excavat^n & earth moving equipment.
(27) O

Factors affecting selection of construction Equipment :-

1. Existing equipments.
2. Availability of equipment
3. Standard Equipment
4. Special equipment
5. Operating cost
6. Manufacturer -
7. Economic life.
8. Type & Duration of project.
9. Cost - Benefit Analysis.
10. Future Use.
11. site condition, power source.
12. Size of equipment.

Owning & operating Cost :-

Following cost constitutes owning & operating cost -

① Depreciation Cost
② Maintenance & operating cost
③ Investment cost
} Yearly Basis

④ Fuel or energy consumption cost
⑤ Lubricating oil cost.
} Hourly Basis.

① **Depreciation cost** :- The loss in value with passage of time is called as depreciation cost; This is due to wear, tear or obsolences.

Methods for determination of depreciation cost :-

① Straight line method.
② Decling Balance method.
③ Double declining Balance method
④ sum-of-the-years-digit mtd.
⑤ sinking fund mtd.

② **Maintenance & Repair cost** :-

It is based on experience & varies with conditions with it is used & care with which it is handled.

Annual maintenance & repair cost is expressed in terms of % of annal cost of depreciation or % depreciation.

Normally, Annual maintenance & repair cost =
50 to 100 % of annual depreciation.

③ **Investment Cost** :-

While investing money on owning or purchasing equipment, owner has to spent money, so chance of interest on the amount invested is lost. Thus, investment cost consist of purchase, taxes, insurance & storage cost.

Normally, Annual investment cost =
10-12% of avg. annual cost.

④ **Fuel or Energy consumption cost** :-

Const^n equipment requires fuel in the form of gasoline oil, diesel or electrical energy & die lubricating oil which is considered as operating cost.

① Engine factor :- The extent to which the engine will operate at full power all the time & time factor.
i.e. actual time that the engine will operate in 1 hr.

② ~~Energy~~ Energy factor :-

Engine factor for power shovel :-

Consider a cycle time of 20 s for power shovel used for

1) filling ~~dumper~~ dipper
2) swinging boom
3) Unloading matl. in waiting truck.
4) swinging back to original position.

The cycle time of 20sec, only 5 seconds are reqd. for filling the dipper, & remaining 15 sec, energine is not operated more than half of its rated HP.

i.e. Engine is rated for filling the dipper (HP) takes 5 sec. remaining time, it is not take $\frac{1}{2}$ of rated HP.

∴ Engine factor ;-

ⓐ Filling the dipper (5 second out of 20 second cycle time operated at unit rated HP)

$= \frac{5}{20} \times 1 = 0.250$.

ⓑ Rest of cycle (15 second out of 20 second cycle time operating at 1/2 rated HP)

$= \frac{15}{20} \times \frac{1}{2} = 0.375$.

∴ Engine factor = 0.250 + 0.375 = 0.625

② Time factor :-

It is world wide phenomenon that driver does not operate engine for all 60 min. of a hr. He must rest 10-15 min. ~~to~~ in a hr. during which he shutts of the engine. Therefore, during this period there is no consumption of fuel. Hence person calculating actual fuel consumption must consider the "actual time" that the engine will operate in a hour.

Time factor of power shovel :-

Consider driver rest for 15 min. in 1 hr.

∴ operating time = 45 sec. min

∴ Time factor = $\frac{45}{60} = 0.75$.

operating factor = engine factor x Time factor

= 0.625 * 75

= 0.469.

∴ Avg. power generated by engine = operating factor x Rated HP.

* For fuel consumption (Lit/hr) = operating factor x Rated HP x 0.30 (Gasoline engine)

* comption of fuel (Lit/hr) = operating factor x Rated HP x 0.20. (Diesel engine)

[common fa operating factor = 0.6]

④ Lubricating oil cost:-

An engine needs lubricating oil for smooth functioning & getting more output at a minimum loss ~~of~~ due to frictional force in the moving parts.

It is common practice to change the oil entirely every 100 - 200 hrs.

* Economic life of construction equipment:-

construction equipment has two types of life estimates -

① Economic life
② Physical life.

Economic ~~life~~ ~~cost~~ life of equipment is defined as the age (in years) of replacement that maximises the profit returns from the equipment or minimizing the cummulative hourly ~~&~~ owning & operating cost.

* Engineering fundamentals of equipment:-

① Rolling Resistance:- Rolling resistance is a measure of force that must be overcome to pull or roll a vehicle over the surface. Soft surface offers higher rolling resistance than hard one. (eg. concrete pavement).

Rolling Resistance depends on -

i) Type of soil / Pavement.
ii) Compaction of soil
iii) size, shape, pressure in tyre.
iv) climatic & weather conditions.
v) condition of soil - dry or wet
vi) SW of equipments.
vii) speed of vehicle etc.

Rolling resistance is expressed in kg of tractive pull reqd. to move each gross tonne over a level surface of the specified tyre condition.

$$R = \frac{P}{W}$$

where, R = Rolling Resistance (kg/tonne)
P = Reqd. Tractive force (kg)
W = SW of vehicle (tonne)

② Grade Resistance:-

It is the measure of force that must be overcome to move a vehicle over rising or falling gradient.

Grade ~~is~~ is expressed in percent slope (% n)

③ Coeff. of Traction:-

The coeff. of traction may be defined as the factor by which the total load on a driving tyre or track should be multiplied in order to determine the max. possible tractive force betⁿ tyre or track & surface just before the slipping will occur.

④ Drawbar Pull:- The term drawbar pull is used in connection with a Crawler Tractor. The available pull which a Crawler tractor can exert on a load that is being towed is known as drawbar pull of the tractor.

⑤ Rimpull:- Rimpull is the term used in connection of rubber tyres of wheel tractors. It defines the tractive force betⁿ the rubber tyres of driving wheels & the surface on which the tyres operate.

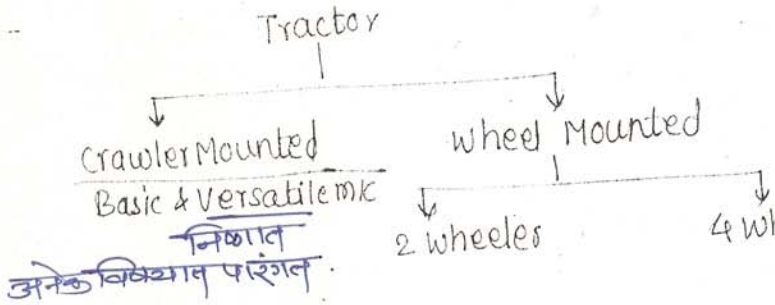
⑥ Gradability:- It is defined as max. slope, expressed as a percent, up which prime mover (a crawler tractor or rubber wheel type tractor), may move at a uniform speed.

Excavating & Transporting Equipments

a] Tractor:-

Purpose :- To pull or push loads
:- Mount for many types of equipment such as bulldozer, shovel, dragline, hoe, benchers etc.

Types :-



Factors affecting selection of Tractor:-
① Size of tractor reqd.
② Kind of Job - bulldozing, pulling, scraper, cleaning etc.
③ High tractive - low tractive eff. reqd.
④ Firmness & smoothness of haul road.
⑤ slope & length of haul.
⑥ Future Use.

Crawler Mounted

① Coeff. of traction = 0.9
② Used for very heavy loads.
③ speed :- avg: 4.5 - 5.6 kmph max = 10
④ Haul dist. is less.
⑤ More initial cost

Wheel Mounted.

① Coeff of traction = 0.6
② Used for light load.
③ Max. speed = 50 kmph.
④ Used when haul dist. is more.
⑤ Less initial cost.
⑥ Loose soil, little or no rock,

b] Bulldozer:- (Versatil equipment)

Use: ① Excavating for short haul applicat° up to 100m.
② Cleaning
③ Temporary road in rocky area.
④ Moving earth for haul dist. up to 100m.
⑤ Helping load tractor pulled scrapers.
⑥ Spreading & levelling of earth fills.
⑦ Back filling of trenches.

Classification:-

Bulldozers (According to)

- Blade Direction
  - Buldozer: Cutting blades are ⊥ar to direct° of travel. It pushes the earth forward.
  - Angledozer: cutting blades are set at some angle with direct° of travel. eg: V-blade. It pushes the earth to one side.
- Control on blade
  - Cable controlled: ① simple to install & work. ② Easy in repair
  - Hydraulic controlled: ① Able to produce high downward pre. on blades to force them into ground. ② Able to maintain precise setting of position of blades.
- Mounting of bulldozer
  - Crawler Mounted: ① Loose & soft Muddy soil & rock. ② Versatile.
  - Wheel Mounted: ① Higher travel speed ② No need of hauling Unit. ③ Able to move on highway.

× Factors affecting type of selection:-

None type is superior to other under all operating condition. Each type has its own advantages & disadvantages under various condition. The factors affecting selection of bulldozer depends on -

① Job requirement.
② Manufacturer limitation.
③ Horse Power of engine
④ Speed range.
⑤ Blade type & size.
⑥ Fuel tank capacity.
⑦ Ground clearance.

× Output of bulldozer:-

Output of bulldozer can be defined as the measure of vol., it handles per hour.

O/p of bulldozer depends on -
① size & condition of bulldozer.
② Haul dist. travelled by bulldozer
③ Operation speed.
④ Soil cht. ⑤ Eff. of bulldozer (Blade Factor)

The blade of bulldozer has theoretical capacity (expressed as Rated mold board capacity) which varies with the class of earth, & size of blade.

Output of bulldozer in bank measure vol. per hr =

$$\frac{\text{Rated mold board capacity in loose vol}}{1 + \text{swell factor}} \times \frac{\text{Actual opening time (m/hr)}}{\text{Time reqd. per trip (min)}}$$

$$\boxed{\text{Time reqd, per trip (min)} = \text{Cycle Time (min)} = \frac{D}{F} + \frac{D}{R} + G}$$

where D = haul dist. (m)
F = forward speed (m/min)
R = Reverse speed (m/min)
G = Gear shifting time (min) = (0.15 - 0.30 min).

Pro: Determine the o/p of bulldozer for the following situations -
a] Matl. handled sandy loam top soil having swell = @ 25%.
b] Haul dist = 30m
c] Rated mold board capacity = 3 m^3 loose vol.
d] Actual operating time per hr = 45 min.
e] Forward speed = 2.4 kmph → as it pushes load. = ~~0.67 m/min~~ 40m/min
f] Reverse speed = 6 kmph → No load. = ~~1.67 min~~ m/min 100m/min.

Soln:- Cycle Time or Time reqd. per trip (min) $= \frac{D}{F} + \frac{D}{R} + G$

$= \frac{30}{40} + \frac{30}{100} + 0.3$ — assume

$= 1.8$ ~~min~~.

$= 1.35$ min.

$\therefore$ o/p of bulldozer $= \frac{\text{capacity}}{1 + \text{swell factor}} \times \frac{\text{operating Time}}{\text{cycle time}}$

$= \frac{3\ m^3}{1.25} \times \frac{45}{1.35}$

$= 80\ m^3/hr.$

~~Theoretically o/p = 3 m^3 x 60 min~~ = 180 m^3/

$\therefore \boxed{\text{o/p} = 80\ m^3/hr}$

V.V.Imp

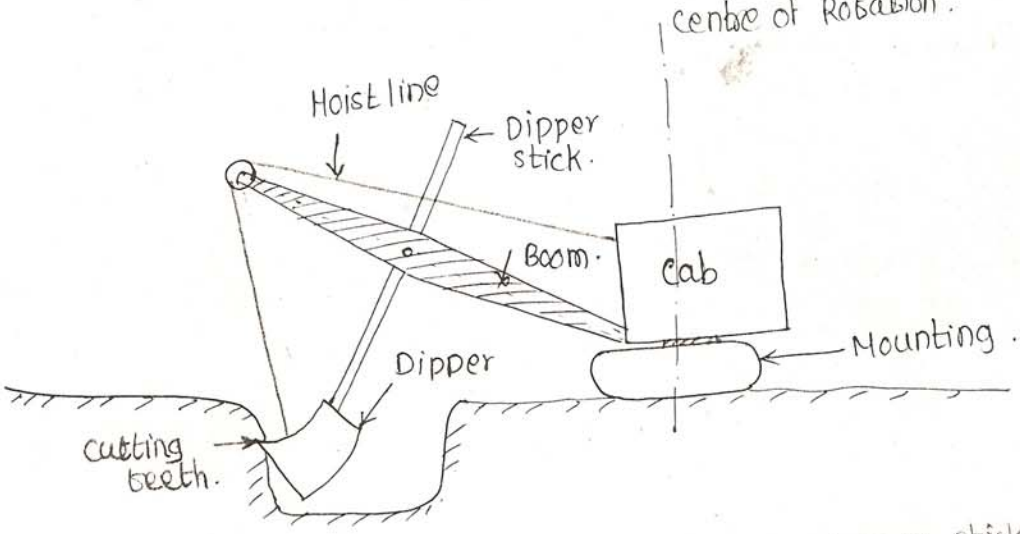
c) Power shovel :- खोदकामासाठी उत्खनन.

Use :- ① Earth excavation & load it into truck.
They are capable of excavating all classes of earth, except solid rock without loosening.

Types :- a) Crawler Mounted
b) Wheel Mounted.

Size : Size of power shovel is indicated by size of "dipper" (m^3) excavat.
= $\frac{3}{8}, \frac{1}{2}, \frac{3}{4}, 1, 1\frac{1}{4}, 1\frac{1}{2}, 2, 2\frac{1}{2}\ m^3$.

Component Parts :- ① Mounting (Crawler / Rubber Tyre wheel)
② Cab
③ Boom
④ Dipper stick
⑤ Dipper & hoist line.



Working :- ① Release hoist to bring dipper down & move stick in vertical plane.
② Dipper is moved forward & downward with cutting teeth pointing towards face of excavation.
③ Apply downward force on dipper through dipper stick.
④ Fill the dipper & pull hoist.
⑤ swing the machine for duming.
⑥ open the door by trip arrangement.
⑦ Bring it to excavated position by swinging & Repeat step ①

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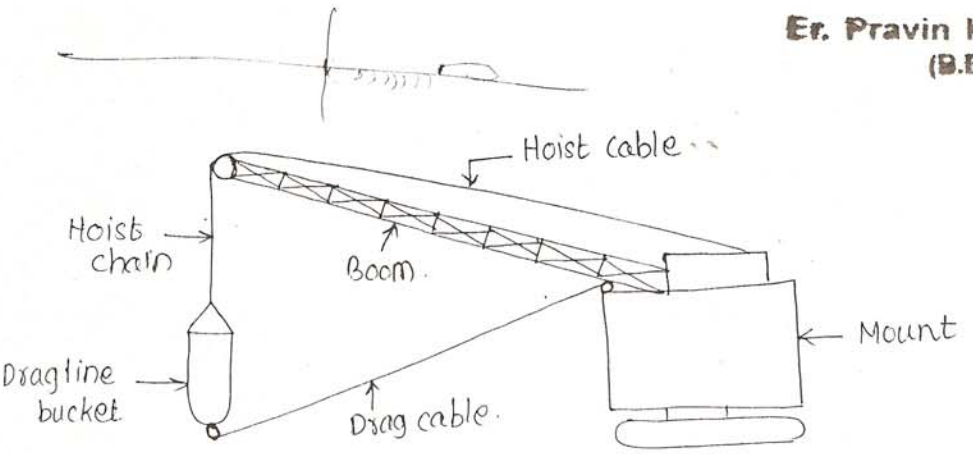


Size of dragline :-

Size of dragline is expressed by capacity of bucket (m^3).

Power shovel up to capacity 1·9 m^3 can be converted in to drag line by replacing boom of shovel with crane boom & substituting dragline bucket for shovel dipper.

Output of dragline :-

$$\text{Output of dragline } m^3/hr = \frac{\text{Vol. of bucket}}{1 + \text{swell factor}} \times \frac{\text{actual time}}{\text{cycle time}} \times \text{efficiency.}$$

Factors affecting output :-

1. Type of matl.
2. Depth of cut.
3. cycle time.
4. Length of boom
5. Angle of swing
6. Job condition.
7. skill of operator.
8. Physical conditions of machine.

Imp.

* Diff bet° Power shovel & Dragline :-

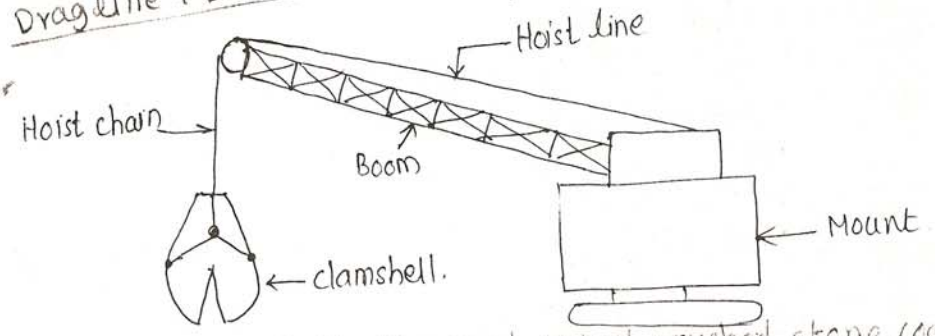
① Dragline usually does not have to go in to the pit for excavation. It may operate on firm ground as length of boom is more, hence it can reach to longer dist.	① Power shovel has to go in to the pit for excavation. as length of boom is less, it can not reach to longer dist.
② Useful when earth is removed from ditch, canal or pit containing water.	② Cannot use for removing earth from ditch, canal, which contains water.
③ Excavated earth is disposed on nearby banks or dam, which is done in single operat°. no need of hauling unit.	③ It cannot dispose matl at some dist. & requires hauling unit ∴ cycle time increases.

e) Clamshells:-

Clamshell is a ~~maching~~ machine having cht. of dragline & crane in common. Digging is done like dragline & once bucket is filled, it works like a crane.

It consist of bucket of two halves which are highed at top.

Clamshells:- Dragline + Crane



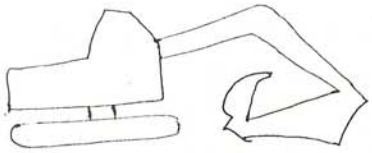
Use: Handling loose matl. like sand, gravel, crushed stone, coal.
Removing matl. from coffer dam, pier found^n, sewer manholes.
Vertical lifting.

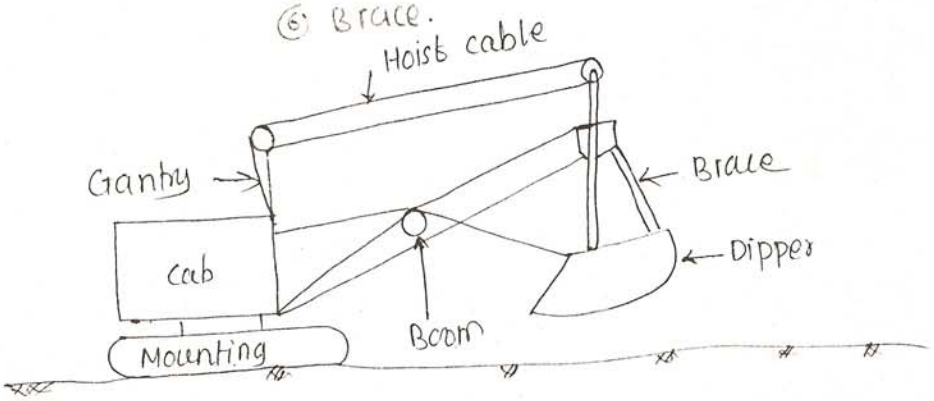
Types:- ① Light bucket
② Heavy Bucket

f] Hoe:- [Backhoe / Back shovel / Pull shovel]

Use:. Hoe is excavating equipment of Power shovel group.

Component :- ① Mounting.
② Boom.
③ Dipper
④ Hoist cable
⑤ Gantry
⑥ Brace.





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* **Choice of Type :-** Crawler mounted / wheel mounted :-
for selecting type of power shovel, following factors are considered -
① Job location.
② Soil condition.
③ Desired mobility.

* **Choice of Size :-** [3/8, 1/2, 3/4, 1, 1 1/4, 1 1/2, 2, 2 1/2]
① Cost of per m^3 of output.
② site condition.
③ Size of Job
④ Project duration.

* **Optimum depth of cut :-** Optimum depth of cut is that depth which produces the greatest o/p & at which the dipper comes up with full load without excessive downward pressure & Tension. This depth varies with type of soil & size of dipper.

4 imp * **Output of power shovel :-**
Output of power shovel is expressed in m^3/hr.

$$\text{Output of shovel } (m^3/hr) = \frac{\text{Loose vol. of dipper}}{1 + \text{Swell fraction}} \times \frac{\text{Actual time (s/hr)}}{\text{cycle Time (s)}} \times \text{efficiency}$$

Pro: Find the o/p of $2\,m^3$ power shovel excavating matl. whose swell is 25%. It handles an avg. heaped loose vol. of $2.25\,m^3$ with cycle time of 27 sec.

* In one cycle, vol. of excavating matl = $2.25\,m^3$ loose.
swell = 25%
∴ Bank measure vol. of one cycle = $\frac{2.25}{1.25} = 1.8\,m^3$.
Assume 10 min. idle Time for every 1 hr.
∴ Actual Time / hr = 50 min = 50 × 60 sec.
∴ No. of cycles / hr = $\frac{50 \times 60}{27}$ =
∴ o/p of shovel = Bank measure vol. in one cycle (m^3) × No. of cycle per hr

$$= 1.8 \times \frac{50 \times 60}{27} = 200\ m^3/hr.$$

Imp * Factors affecting o/p of power shovel:-

① Type of soil.
② Depth of cut :- For shallow depth ⇒ More cycles ⇒ More %
③ Angle of swing.
④ & Cycle Time :- lesser the cycle time ⇒ Higher the o/p.
⑤ Job conditions.
⑥ Management condition.
⑦ size of hauling units.
⑧ skill of operator.
⑨ swelling index.
⑩ Maintenance & repairing of shovel.

* Methods of improving o/p of power shovel:-

① Working cycle should be smooth, well balanced, well managed
② Have clear & min. swing.
③ Avoid waiting time.
④ Proper position of shovel.
⑤ Sharp dipper tip

V.Imp d] Drag line :- [Drag: To pull slowly]

Use:- Basic character of dragline is dragging the bucket against the matl. to be dug.
: To excavate the earth & load into hauling unit or to deposit into dam/embankments or spoil banks near the pit.

Types:- ① Crawler mounted
② Wheel mounted
③ Truck mounted.

* Components:- ① Mount
② Crane-boom
③ Hoist cable
④ Hoist chain
⑤ Dragline bucket
⑥ Drag cable.

Operation:- ① Swing the empty buck to digging position.
② Pull the bucket toward machine.
③ Digging depth is maintained by tension in hoist cable.
④ Fill the bucket.
⑤ Hoisting, swinging & emptying/dumping the loaded bucket.
⑥ Repeat setp ①.

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operation:- ① Set boom at desired angle
② Move the dipper at desired position.
③ Release the hoist, so that dipper digs the matl.
④ Fill the dipper by pulling cable.
⑤ Raise & swing to duming position.

The 'hoe' can exert greater tooth pressure, so that it can be used in quarries ~~with~~ which have & tough digging conditions.

Use:- ① Excavat^n below GL
② Dig trenches, basement & work where precise depth is reqd.
③ Dumping in trucks.

g] Scraper:-

Scraper is a machine which can scrap the ground & load it simultaneously, transport it over reqd. distance, dump at desired place & spread the dumped material over the required area in required level & return to pit for next cycle.

∴ Uses:- Dig
load
dump
spread

Not suitable for:- ① Hard Rock
② certain sands
③ Wet & muddy matl.

components:- ① Bowl : To hold scrap matl.
② cutting edge
③ Apron
④ Tail gate or ejector

Types:- ① Crawler ~~mounted~~ -Tractor scraper
② wheel tractor scraper
③ Motor scraper.

o/p of scrapper:-

$$\text{o/p } (m^3/hr) = \frac{Vol \times S \times \frac{60}{t} \times n}{}$$

S = ~~Swell factor~~
t = cycle time per trip (m)
t = fixed time = (loading + Dumping & turning + (m) accelerat^n + Decelerating + Haul time + Return time.
n = efficiency.

factors affecting o/p:
① Size & mechanical conditions of scrapper
② cht. of soil.
③ Hauling dist.
④ Climatic cond^n