Mobile Equipment Power Requirements

Required Power:

Total Resistance = Rolling Resistance (R.R) + Grade Resistance (G.R)

1. Rolling Resistance:

It is the resistance of a level surface to constant velocity motion a cross it.

✪ For equipment which move on ***rubber tires*** the rolling resistance varies with:

- The size.
- Tread designed of the tires.
- Pressure on (Contact area)

For equipment which moves on ***crawler tires*** such as tractors the resistance varies primarily with:-

- Type and Condition of road surface.

The unit of rolling resistance is: **kg /ton or lb/ton**

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

Where:

R.R = Rolling resistance kg or lb / ton

P = total tension in two cable lb or kg

W = gross weight of truck (ton)

☞ **R.R of crawler equipment start from 50 kgf / ton or 110 lb / ton**

TABLE 6.1 Representative rolling resistances for various types of wheels and crawler tracks versus various surfaces*

	Steel tires, plain bearings		Crawler type track and wheel		Rubber tires, antifriction bearings			
					High pressure		Low pressure	
Type of surface	lb/ton	kg/m ton	lb/ton	kg/m ton	lb/ton	kg/m ton	lb/ton	kg/m ton
Smooth concrete	40	20	55	27	35	18	45	23
Good asphalt	50–70	25–35	60–70	30–35	40–65	20–33	50–60	25–30
Earth, compacted and maintained	60–100	30–50	60–80	30–40	40–70	20–35	50–70	25–35
Earth, poorly maintained	100–150	50–75	80–110	40–55	100–140	50–70	70–100	35–50
Earth, rutted, muddy, no maintenance	200–250	100–125	140–180	70–90	180–220	90–110	150–200	75–100
Loose sand and gravel	280–320	140–160	160–200	80–100	260–290	130–145	220–260	110–130
Earth, very muddy, rutted, soft	350–400	175–200	200–240	100–120	300–400	150–200	280–340	140–170

*In pounds per ton or kilograms per metric ton of gross vehicle weight

2. **The effect of grade on required tractive effort:** Tractive effort of vehicles is the effort required to keep it moving increase or reduces approximately in proportion to the slope of the road , and this tractive effort is to increase with plus slope or decrease with minus slope , this tractive effort can be calculated from:

$$\textit{Tractive Effort} = W \times 10 \times \%G \Rightarrow kg$$

$$= W \times 20 \times \%G \Rightarrow lb$$

Where:

W: gross weight of truck (ton). **G:** Slope %

3-Coefficient of Traction:

To determine the maximum possible tractive force between the tire or track and the surface just before slippage occurs.

$$\textit{Coefficient of traction} = \frac{\textit{Tractive force}}{\textit{total pressure between tractive and road surface or (effective vehicle weight)}}$$

- For track type Use total tractor weight
- 4- Wheel tractor 40% of vehicle gross weight
- 2- Wheel tractor 50% of vehicle gross weigh

Typical values of coefficient of traction for common surfaces are given in table

Surface	Rubber Tires	Crawler tracks
Dry, rough concrete	0.8-1.0	0.45
Dry, clay loam	0.5-0.7	0.9
Wet, clay loam	0.4-0.5	0.7
Wet, sand and gravel	0.3-0.4	0.35
Loose, dry sand	0.2-0.3	0.3
Dry snow	0.2	0.15-0.35
Ice	0.1	0.1-0.25

4. The effect of altitude on the performance of internal combustion engines:

An internal combustion engine operates by combining oxygen from the air with the fuel. The density of the air is reduced because of altitude, so the quantity of oxygen in a given volume of air will be less than for the same volume of air at sea level.

This can calculate from:-

$$\textbf{Loss due altitude} = \textbf{hp} \times 0.03 \times \frac{H-300}{300} \Rightarrow m$$

$$= \textbf{hp} \times 0.03 \times \frac{H-1000}{1000} \Rightarrow ft$$

Effective power = sea level power – Loss due altitude

5-Combined effect of pressure and temperature on the performance of internal combustion engine:

$$H_c = H_o \frac{P_s}{p_o} \sqrt{\frac{T_o}{T_s}}$$

Where:-

H_c : corrected hp for standard conditions.

H_o : observed hp as determined from test.

P_s : standard pressure = 29.92 in. Hg

= 760 mm. Hg

P_o : observed pressure at time of test.

T_o : absolute temperature °***F = 460 + observed Temperature.***

°***C = 273 + observed Temperature.***

T_s : absolute temperature for standard conditions 520°F; 288 °C

6. Rim pull:-

Is the tractive force between the rubber tires of driving wheels and the surface on which they travel.

It may be determined from the formulas:-

$$\textbf{Rimpull} = \frac{375 \times hp \times efficieny}{speed\ ,mph} \quad \textbf{(lb)}$$

$$\textbf{Rimpull} = \frac{272.2 \times hp \times efficency}{speed\ km/hr} \quad \textbf{(kg)}$$

*The efficiency of most tractors and trucks will range from **80 to 85 percent.***

7. Drawbar Pull :-

The force that can be developed to tow a load by crawler tractor.

Example 1:-

Wheel – tractors is used on a road project. The rimpull required or the tractive force required in this work area is 42000 lb. In the fully loaded condition 52% of the total vehicle weight is on the drive wheels. The fully loaded vehicle weight is 230880 lb. What is the minimum value of the coefficient of traction needed to maximum possible travel speed?

Solution:

52% from weight = 0.52*230880=120058 lb

$$\textit{Coefficient of traction} = \frac{Tractive\ force}{\substack{total\ pressure\ between\ tractive\ and\ road\ surface \\ or\ (effective\ vehicle\ weight)}} = \frac{42000}{120058} = 0.35$$

Example 2:

A tractor whose weight is 15 tons has a drawbar pull of 5684 lb in the sixth gear when operate on a level road having a rolling resistance of 110 lb / ton . If the tractor is operated on a level road having a rolling resistance of 180 lb / ton. What is the effect on drawbar pull will be?

Solution:

P = W * R.R

P= 15 (180 – 110) = 1050 lb

Drawbar pull effective = 5684 – 1050 = 4634 lb

Example 3:- For a rubber tired tractor with 140 hp engine and a maximum speed of 3.25 mph in the first gear with total weights 12.4 ton and is operated up a haul road with slope of 2% and rolling resistance of 100 lb/ ton .What is the pull available.

Solution:

Rimpull effort = $\frac{375*hp*efficiency}{speed} = \frac{375*140*0.85}{3.25}$

= 13731 lb

$P_{Rolling\ resistance}$ = W*R.R

=12.4 * 100 = 1240 lb

P_{grade} = W*20*G%

=12.4* 20* 2 = 496 lb

Total resistance = R.R+G.R = 1240+496=1736 lb

Available rimpull = 13730 – (1240 +496) = 11994 lb

What is the Maximum weight can this equipment works with?

11994 = W_c * 100 + W_c * 20 * 2

$W_{capacity}$ = 85.7 tons

W_{soil} = 85.7- 12.4=73.3 tons

Example 4:

What is the maximum slope that can a wheel type tractor pulled scraper, total weight at the sea level 62840 kg , its rolling resistance 22.9 kg / ton , engine power 300 hp and its speed 16 km / hr .

Solution:

Total Rimpull $= \frac{\mathbf{272.2 \times hp \times efficency}}{\mathbf{speed\ km/hr}} = \frac{272.7*300*0.8}{16} = 4083\ kg$

$P_{RR} = P * R.R = \frac{62840}{1000} * 22.9 = 143.9\ kg$

P_{Grad}= Total Rimpull-P_{RR}

P_{Grad}=4083 – 143 . 9 = 3939.1 kg

P_{Grad}=W*10*G

3939.1 = $\frac{62840}{1000} * 10 * slope$

Slope = 62%

ملاحظات هامه ع حسابات Mobile equipment

* اذا اعطي وزن الاليه بـ kg فيجب ان تحول الى Ton

* $R.R = \frac{P}{W} \Leftarrow P_{rolling} = R.R * W$

(ملاحظات R.R) هامة جداً

١. ع حاله كون الجرار او الاليه مجنزره اي crawler يطرح 50 kg/Ton من الرقم المعطى ع السؤال كالاتي

$$P_{rolling} = (R.R - 50) * W$$

٢. ع حاله طلب ع السؤال جرار يسحب اليه اخرى ولكل منها R.R فتختلف فتكون $P_{rolling}$ كالاتي

$$P_{rolling} = \underbrace{R.R * W}_{\text{للجرار}} + \underbrace{R.R * W}_{\text{الحمله المسحوبه}}$$

** $P_{Grade} = W * 10 * g$ مع ملاحظه ان g نعوض رقم صحيح وليس نسبه

اي اذا اعطى g = 10% نعوض ع معادله الرقم كامل 10

* ع حال طلب ع السؤال net force او available fore يكون الحل كالاتي

available or net fore = Rimpull force − tractive force (P T.R)

$$Rimpull = \frac{272.2 * eff * hp}{speed\ (km/hr)}$$

$$P_{T.R} = P_{rolling} + P_{Grade}$$

* ع حاله اعطاء كثافة التربه المحمله يجب ان تحول لى وزن ويضرب الوزن ع حجم او استيعابية الاليه المسحوبه

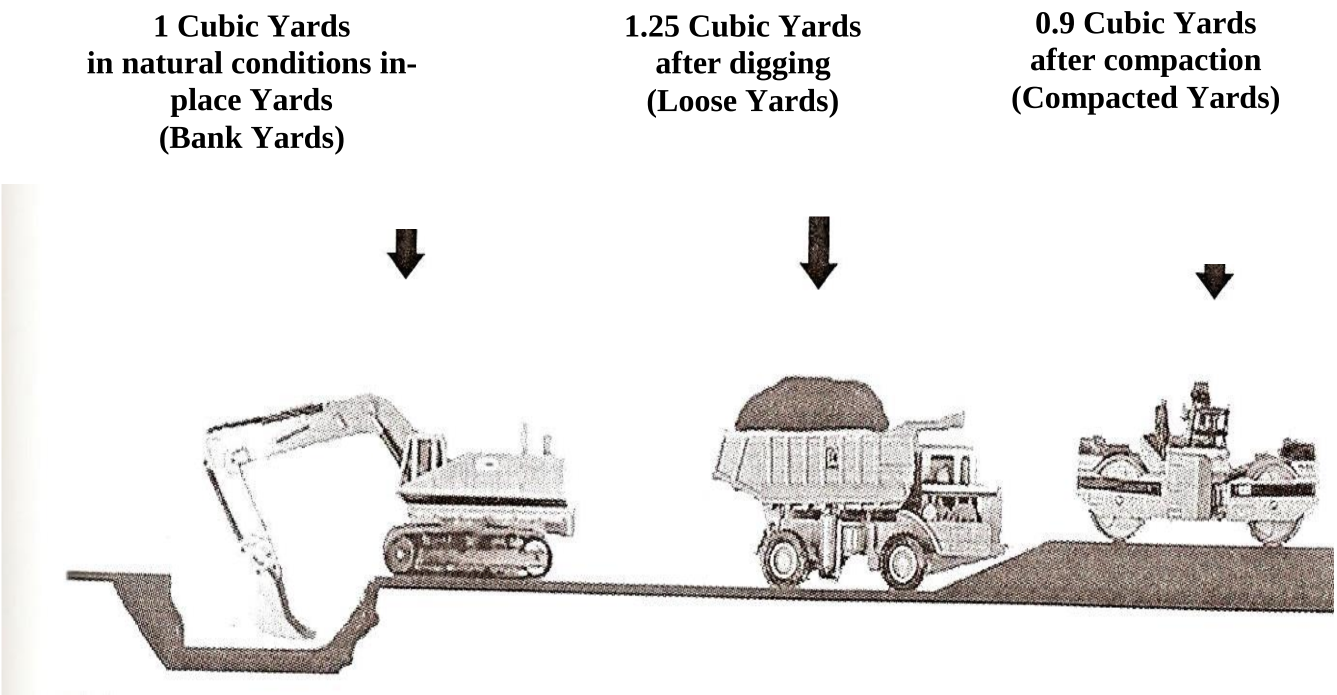
$$\gamma = \frac{W}{V} \Rightarrow W = \gamma * V$$

* ع حاله طلب قوة الجر اللازمه tractive fore

$$\text{tractive fore} = P_{R.R} + P_G$$

Soil Stabilization and Compaction

Volumetric Measure: For bulk materials volumetric measure varies with the materials position in the construction process see figure below, the same weight of a material will occupy different volumes as the material is handling on the project.



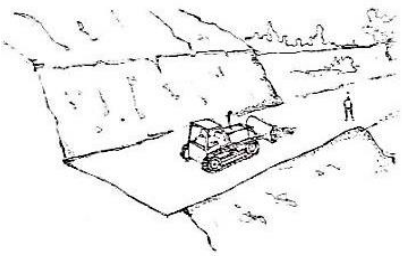
<u>Soil volume is measured in one of these states</u>:-

Bank cubic yard or meter: one cubic yard or one cubic meter of material as it lies in the natural state (B_{cy} or B_{cm})

Loose cubic yard or meter: one cubic yard or one cubic meter of material after it has been distance by a loading process (L_{cy} or L_{Cm}).

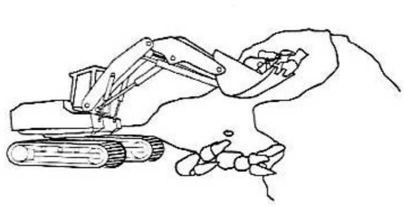
Compacted cubic yard or meter: one cubic yard or one cubic meter of material in the compacted state (C_{cy} , C_{cm})

Bank cubic meter



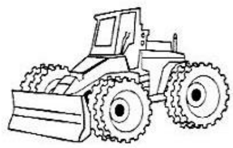
1 cubic meter (m^3) of material as it lies in the natural state

Loose cubic meter



1 m^3 of material after it has been disturbed by a loading process

Compacted cubic meter



1 m^3 of material in the compacted state

❖ In planning or estimating a job, the engineer must use a consistent volumetric state in any set of calculations. The necessary consistency volumetric of units can achieve by:

$$\textbf{Shrinkage factor} = \frac{\textbf{compacted dry unit weight}}{\textbf{bank dry unit weight}}$$

$$\textbf{Shrinkage \%} = \frac{\textbf{compacted unit weight} - \textbf{bank unit weight}}{\textbf{compacted unit weight}} \times \mathbf{100}$$

$$\textbf{Swell factor} = \frac{\textbf{loose dry unit weight}}{\textbf{bank dry unit weight}}$$

$$\textbf{Swell \%} = \left(\frac{\textbf{bank unit weight}}{\textbf{loose unit weight}} - \mathbf{1}\right) * \mathbf{100}$$

$$\mathbf{C}_{cy_m} \ \textbf{or} \ \mathbf{C}_{cm_m} = \mathbf{B}_{cy_m} \ \textbf{or} \ \mathbf{B}_{cm_m} \ (\mathbf{1- sh \ \%})$$

$$\mathbf{L}_{cy_m} \ \textbf{or} \ \mathbf{L}_{cm_m} = \mathbf{B}_{cy_m} \ \textbf{or} \ \mathbf{B}_{cm_m} (\mathbf{1+ sw \ \%})$$

TABLE 4.4 Representative properties of earth and rock

Material	Bank weight lb/cy	Bank weight kg/m³	Loose weight lb/cy	Loose weight kg/m³	Percent swell	Swell factor*
Clay, dry	2,700	1,600	2,000	1,185	35	0.74
Clay, wet	3,000	1,780	2,200	1,305	35	0.74
Earth, dry	2,800	1,660	2,240	1,325	25	0.80
Earth, wet	3,200	1,895	2,580	1,528	25	0.80
Earth and gravel	3,200	1,895	2,600	1,575	20	0.83
Gravel, dry	2,800	1,660	2,490	1,475	12	0.89
Gravel, wet	3,400	2,020	2,980	1,765	14	0.88
Limestone	4,400	2,610	2,750	1,630	60	0.63
Rock, well blasted	4,200	2,490	2,640	1,565	60	0.63
Sand, dry	2,600	1,542	2,260	1,340	15	0.87
Sand, wet	2,700	1,600	2,360	1,400	15	0.87
Shale	3,500	2,075	2,480	1,470	40	0.71

*The swell factor is equal to the loose weight divided by the bank weight per unit volume.

Soil Compaction

Compaction can:

1. Reduce settlements.
2. Increase strength.
3. Improve bearing capacity.
4. Control volume changes.
5. Lower permeability.

$$\text{Degree of Compaction \% (D)} = \frac{\text{Maximum dry density (in field)}}{\text{Maximum dry density (in lab)}}$$

✪ Specifications → D ≥ 95 – **100** %

Example:-

If the earth is placed in fill as a compacted soil at the rate of 200 C_{cyd} / hr.

How many Loose (cyd / hr) must be supplied if the compacted, bank, loose unit weight are (C=2890,B=2590, L=2390) lb/ cyd

Solution:

$$\textbf{Shrinkage \%} = \frac{\textbf{compacted unit weight} - \textbf{bank unit weight}}{\textbf{compacted unit weight}} \times \mathbf{100}$$

$$\text{Shrinkage \%} = \frac{2890-2590}{2890} * 100 = 10{,}38\%$$

$C_{cy} = B\,cy_m$ (1-sh%) $B_{cy} = \frac{200}{0.8962} = 223.1$ cyd

$L_{cy} = B\,cy_m$ (1 + sw %) $\textbf{Swell \%} = \left(\frac{\textbf{bank unit weight}}{\textbf{loose unit weight}} - \mathbf{1}\right) * \mathbf{100}$

$$\text{Sw \%} = \left(\frac{2590}{2390} - 1\right) * 100 = 8.36\%$$

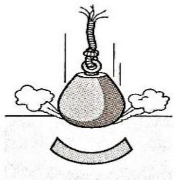
Loose /$_{\mathbf{cy}}$ = 223.16 (1+ 0.0836) = 241 . 8 cy

TABLE 5.1 Soil types versus the method of compaction

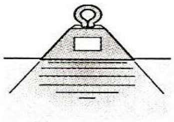
Material	Impact	Pressure	Vibration	Kneading
Gravel	Poor	No	Good	Very good
Sand	Poor	No	Excellent	Good
Silt	Good	Good	Poor	Excellent
Clay	Excellent with confinement	Very good	No	Good

METHODS OF COMPACTING EQUIPMENT

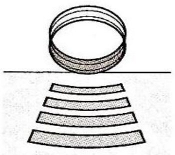
Applying energy to a soil by one or more of the following methods will cause compaction:



1. Impact—sharp blow



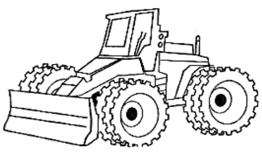
2. Pressure—static weight



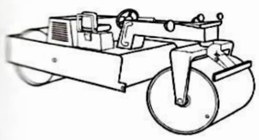
3. Vibration—shaking

4. Kneading—manipulation or rearranging

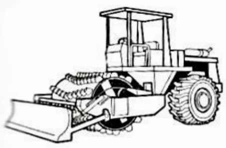
Types of Compaction Equipment



1. Tamping rollers



2. Smooth-drum vibratory soil compactors



3. Pad-drum vibratory soil compactors

4. Pneumatic-tired rollers

1. Pad foot rollers:

Used for clays, mixtures of sand and clay.

2. Sheeps foot rollers:

Used for soil containing rocks

3. **Smooth wheel rollers:** Sand, gravel, crushed stone may have one or more drums

4. **Pneumatic tired rollers:** sand, gravel and pavement surface.

5. Vibrating Compactors: sand, gravel, rock.

Manually operated
vibratory-plate compactor
crushed Aggregate

Manually operated
Rammer compactor

Roller Production Estimating:-

Compacted cubic yards or meters per hour = $\frac{\mathbf{W \times S \times L}}{\mathbf{P}}$

Where:

W : compacted width per roller pass $\Rightarrow$ ft or meter .

S : average roller speed $\Rightarrow$ mph or km/h

L : compacted = compacted lift thickness$\Rightarrow$ ft or meter.

P : number of roller passes required to achieve the required density.

Example:

A self –propelled tamping foot compactor will be used to compact a fill being constructed of clay material. Field tests have shown that the required density can be a achieved with four passes of the roller operating at an speed of 1.5mph , the compacted lift will have a thickness of equal 5 in , the roller width is 7 ft , the scraper production estimated for the project is 510 bcy per hour . shrinkage %=17%,How many rollers will be required to maintain this production?

Solution:

foot to yd ÷3

mile to yd *1760

inch to foot ÷ 12

Production of roller/hr =$\frac{W \times S \times L}{P} = \frac{\frac{7}{3} \times 1.5 \times 1760 \times \frac{5}{3 \times 12}}{4} = 214\, \frac{cyd}{hr}$

$C_{cy} = B\, cy_m$ (1-sh%)=214

B cyd/hr =214/(1-0.17)=258 Bank cyd

No.of rollers = $\frac{Prouction\ of\ Scraper}{productio\ of\ Roller}$510/258=1.97 rollers

Soil Stabilization

Soil stabilization is any treatment of soil which increases its natural strength, there are two kinds of stabilization:-

1-Mechaincal

2-Chemical

Methods of stabilization soils included, but are not limited to, the following operations:

1. Blending and mixing heterogeneous soils to produce more homogeneous soils.
2. Incorporating lime or lime-fly ash into soils that have high clay content.
3. Blending asphalt with the soil.
4. Incorporating Portland cement with soils they are largely granular in nature.
5. Incorporating various salts into the soil.
6. Incorporating certain chemicals into the soil.
7. compacting the soils after they are processed

Tractors

Are self-contained units that are designed to provide tractive power for drawbar work, because they are low center of gravity machines.

Tractors are classified on the basis of running gear to:

1. **Crawler Track.**
2. **Wheel Track.**

	Wheel Tractor		Crawler Tractor
1	Good on firm soils and concrete.	1	Can work on a variety of soils.
2	Best for level and downhill work.	2	Can work over almost any terrain.
3	Wet weather, causing soft and slick surfaces conditions, will stop operation.	3	Can work on soft ground, and over mud- slick surface.
4	Good for long travel distance.	4	Good for short work distance.
5	Fast return speeds 8-20 mph	5	Slow return speed 5-7 mph
			

Applications:

- Land clearing.

- Bulldozing.

- Ripping.

- Towing other pieces of construction equipment.

Selecting of tractor:-

In selecting tractor several factors should be considered:

1. The size required for a given job.
2. The kind of job for which it will be used.
   - Bulldozing.
   - Pulling a scraper.
   - Ripping.
   - Clearing land, etc.
3. The type of ground over which it will operate.
4. The firmness of the haul road.
5. The smoothness of the haul road.
6. The slope of the haul road.
7. The length of haul road.
8. The type of work it will do after this job is completed

Bulldozer

Is a tractor unit that has a blade attached to the machine front. It is designed to provide attractive power for drawbar work. The amount of material the dozer moves is dependent on the quantity that will remain in front of the blade during the push.

Bulldozers are used in:

1. It is used in moving earth or rock for short hand (push) distance up to 300 ft. (91 m) in the case of large dozers.
2. Leveling of land (Spreading earth)
3. It is used in backfilling trenches.
4. It is used in opening up roads through mountains or rocky terrain.
5. Clearing the site from the rubble.
6. Helping load tractor –pulled scrapers.
7. It is used in clearing land of timber, stumps, and root mat.

Types of Dozers:

1. Crawler Dozer
2. Rubber–tired Dozer

Blade moving:

- By Cable
- Hydraulically

Crawler Bulldozer

Rubber tired Bulldozer

Blades: A bulldozer blade consists of a moldboard with replaceable cutting edges and side bits.

There are five types of blades which are:

1.Straight (S) blade: is designed for short and medium distance passes, such as backfilling, grading and spreading fill material.

2.Angle blades (A): is wider (face length) by 1to 2 ft. than (S) blade. It can be angle up to a maximum of 25 degrees left or right to the dozer line of travel used for side casting material, backfilling or making side hill cuts.

3-Universal blade (U): Its blade is wider than a straight blade and having a 25° wings to reduce the loose soil spillage.

4- Semi – U (SU) blade: It is similar to the U type but with shorter wings.

5- Cushion (C) blade: Its blade is shorter than a straight blade. It is usually mounted on large dozers that are used to push-loading scrapers.

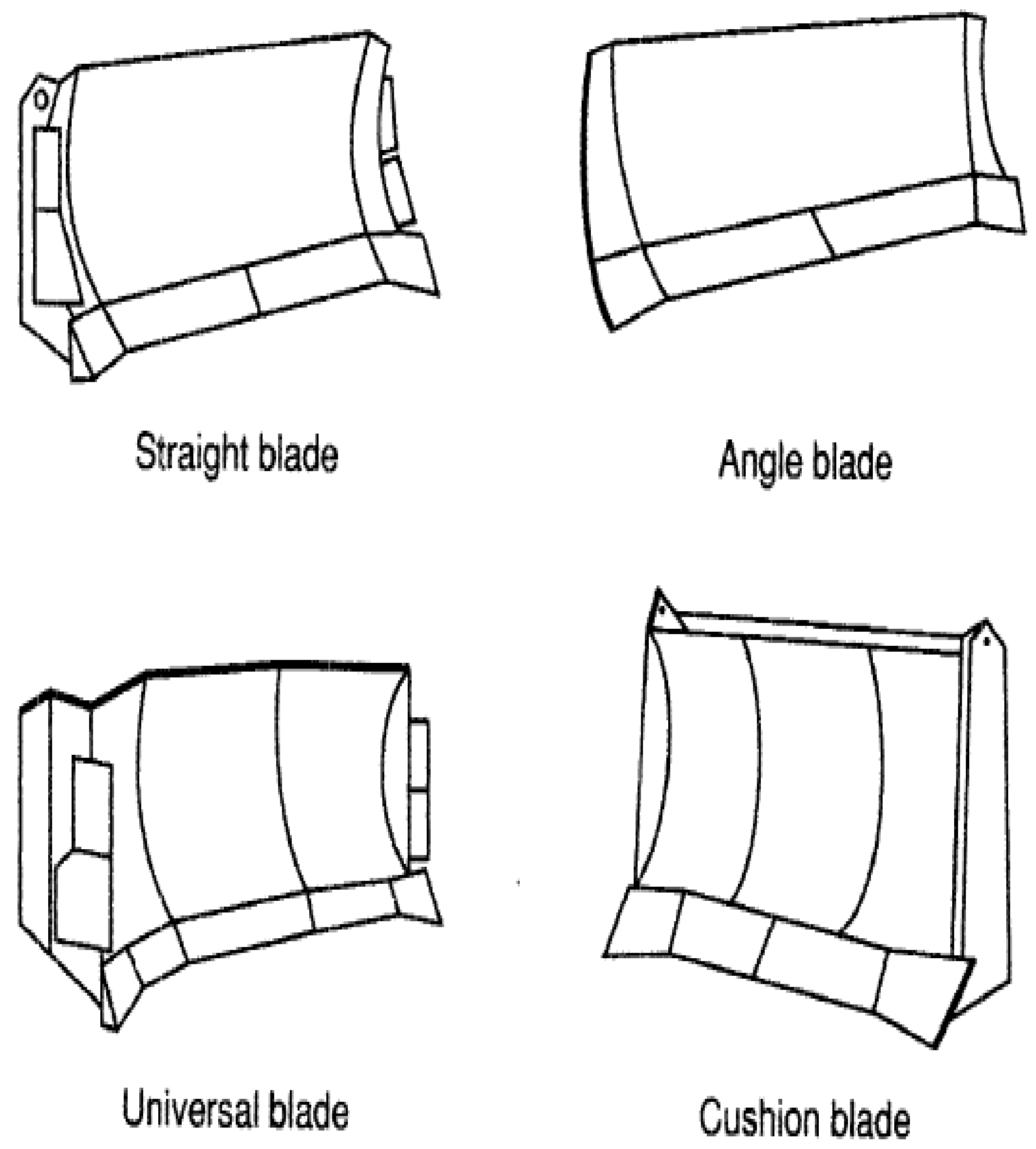
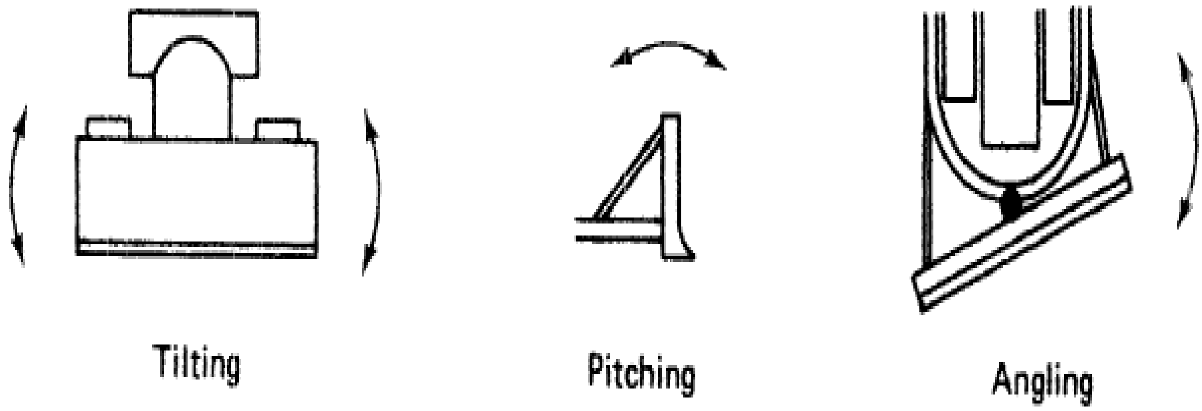


Figure 4–7 Common types of dozer blades.



Bulldozer Production estimating:

The amount of material that the dozer moves depends on the quantity which will remain in front of the blade during the push. The production depends on:

1-The blade type.

2-The type and condition of material.

3-The cycle time.

The load that a blade will carry can be estimated by several methods:-

1. The manufacture blade ratings.
2. The previous experience (similar material equipment, and work conditions).
3. The field measurements.

The manufactures usually provide a blade rating that is based on:

Vs = 0.8 LH²

$$V_s = 0.8\ LH^2$$

Where:

Vs = capacity of straight or angle blade.

L= blade length or width in m or yd

H= effective blade height in m or yd

Example:

Estimate the approximate output of a bulldozer for the following conditions:−

The soil is a sandy loam of density 2700 lb per cu yd bank measure, swell 25%, Haul distance 100 ft . Crawler tractor 72 hp, straight blade size 9 ft 6 in

L = 9.5 ft H = 3ft ,Fixed time =0.32 min.

Operating factor 50 min per hr

Pushing along 100 ft distance at a speed of 1.5 mph.

Returning the 100 ft distance at a speed of 3.5 mph.

Solution:

$$Production\ of\ bulldozer/\ hour\ =\ capacity\ of\ blade\ \times No.of\ trip/\ hr$$

$$Capacity\ of\ blade\ =\ 0.8L\ H^2$$

$= 0.8 \times\ 3.1 \times\ 1^2 = 2.48$ cy Loose measure .

$$No.of\ Trip\ /\ hour\ =\ \frac{operating\ factor}{cycle\ time}$$

$$Cycle\ time\ =\ pushing\ time\ +\ Returning\ time\ +\ fixed\ time$$

$$pushing\ time = \frac{\frac{100}{5280\ (\frac{ft}{mi})}}{1.5} \times 60\frac{min}{hr} =$$

Cycle time = $\frac{\frac{100}{5280}}{1.5} \times 60\ + \frac{\frac{100}{5280}*60}{3.5} + 0.32 = 1.402$ min

No.of Trip / hour = $\frac{\boldsymbol{Operating\ factor}}{\boldsymbol{cycle\ time}} = \frac{50}{1.402} = 35.6$

$$Production\ of\ bulldozer/\ hour\ =\ capacity\ of\ blade\ \times No.of\ tripe/\ hr$$

Out put = $\frac{2.40}{1+0.25} * 35.6$ = 68.3 cy bank measure

Example:

A (D7G) crawler tractor with a straight blade is to be used in dozing operation to a site with dimensions (50×100) m .find the minimum time in hours needed to excavate this site with a depth of 30 cm with the below information:−

Blade dimension type S (0.97×2.9) m

Operation factor 50 min / hr Swell % = 25 %

Push speed 2.4 km/ hr

Return speed 5.6 km / hr Fixed time = 0.32

Solution:

$$Production\ of\ bulldozer/\ hour\ =\ capacity\ of\ blade\ \times No.of\ trip/\ hr$$

$$\boldsymbol{Capacity\ of\ blade\ =\ 0.8L\ H^2}$$

$$= 0.8 \times\ 2.9 \times\ 0.97^2 = \mathbf{2.18\ m^3}$$ Loose measure.

$$\boldsymbol{Cycle\ time\ =\ pushing\ time\ +\ Returning\ time\ +\ fixed\ time}$$

Cycle time = $\frac{\frac{100}{1000}*60}{2.4} + \frac{\frac{100}{1000}*60}{5.6} + 0.32 = 3.9\ min$

$$No.of\ Trip/hour\ =\ \frac{operating\ factor}{cycle\ time} = \frac{50}{3.9} = 12.82$$

Out put $(\boldsymbol{Production\ of\ bulldozer/\ hour}) = \boldsymbol{capacity\ of\ blade\ \times No.of\ trip/\ hr}$

$$= \frac{2.18}{1+0.25} * 12.82 = 22.35\ m^3\ bank\ measure$$

Min.Time = volume/output$(100*50*0.3)$ / 22.35 = 67 hr

Cycle time = $\frac{\frac{50}{1000}*60}{2.4}+\frac{\frac{50}{1000}*60}{5.6}+0.32=2.105\ min$

Trip / hr = 50/ 2.105 = 23 . 75

Out put = $\frac{2.18}{1.25}*23.75=41.42\ m^3\ \ bm$

Volume=(100*50*0.3)=1500

Min. Time = volume/output= $\frac{1500}{41.42}=36.21\ hr$

Scrapers

1. Introduction:

The scraper is an equipment which is used to excavate, load, haul, and dump soil over a medium to long hauling distances. It excavates or cuts the soil by lowering the front edge of its bowl into soil.

A typical type of such equipment is shown in Fig.(1) below.

The scrapers are usually used for a haul distance in the range of (150 – 900m). For longer hauling distances, a combination of tucks and scrapers may be needed.

A typical working cycle for scraper is shown in Fig.(2) below:

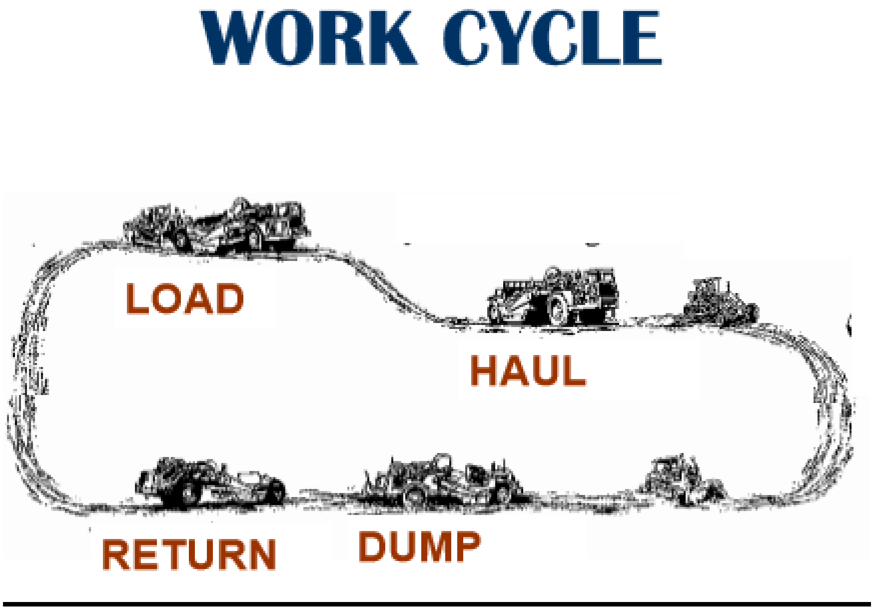


Fig.(2): Scraper Working Cycle.

2. Scraper Types:

The main types of scrapers are:

1. Pusher-Loaded scrapers.
2. Self-loading scrapers.

For easy to load soil (i.e not for a rocky ground), a self-loading scraper may be used up to a haul distance of about 250m. For longer haul distances a pusher-loaded scraper is required to assist in using the scraper for loading and transporting of soil.

A Crawler-Tractor towed Two Scrapers.

Pusher-Loaded Scrapers:

The main types of these scrapers are:

1. Crawler-tractor towed two axle scrapers,

2. Pusher-loaded scraper:

-Single-powered axle

-Tandem-powered axles: The heavier scraper types have two engines ('tandem powered'), one driving the front wheels, one driving the rear wheels.

Self-Loading Scrapers:

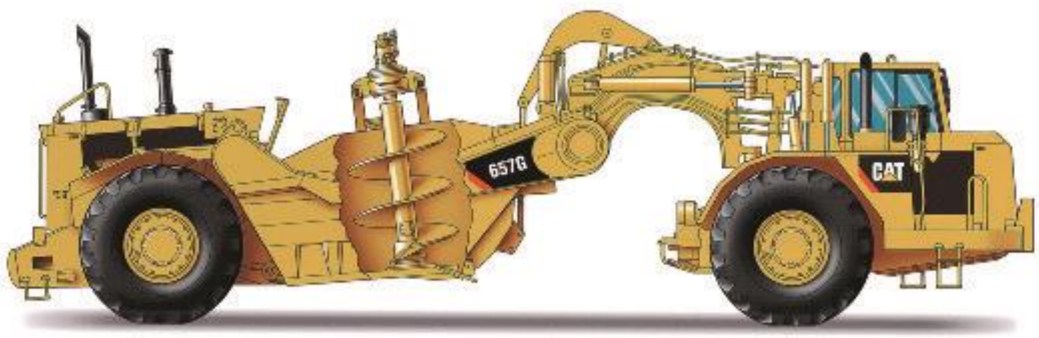
The main types of these scrapers are:

Type(1):. Elevating wheel-tractor scraper:

In which a chain elevator is mounted on the front of the bowl to increase the amount of the collected soil in the bowl. It is economical to be used in short hauling distances.

Type(2): Auger type:

It is usually used in difficult conditions such as laminated rocks, granular or frozen soils.



Example:-

For the haul conditions as stated below, analyze probable scraper production if the total length of haul when moving from the cut to the fill is 4000 ft as follows:-

Soil density = 3100 lb / bank cy

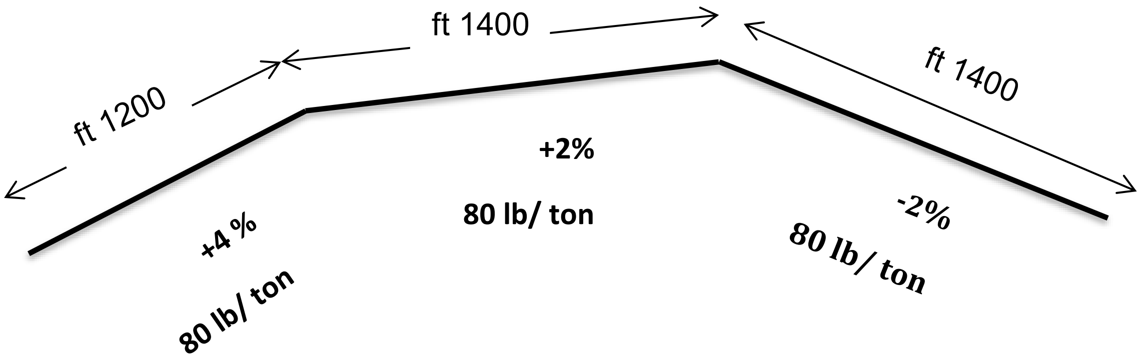
Average load time of 0.85 min and the expected load from load growth curve will be 96% of capacity.

Swelling 25%

Capacity of scraper(heaped) = 31 cu-yd

Weight of scraper empty = 96880 lb

Fixed time equal to 0.45 min.



Solution:

$$Production\ of\ scraper\ =\ capacity\ \times\ No.of\ cycles\ (\ trip\ /\ hr)$$

Capacity = $31\ \times\ 0.96 = 29.76\ \ Loose\ cy$

$$\frac{29.76}{1+(\ sw\ \%-10)} = \frac{29.76}{1+(\ 25\%-10\%\ )} = 25.8\ 7\ Equivalent\ Bank\ cy$$

$weight\ of\ scraper\ with\ clay = 96880 + 25.8 \times 3100 = 176860$ lb

No. of cycle/hr.=$\frac{operation\ factor}{cycle\ time}$

No. of cycle / hr. = $\frac{50^*}{\text{Cycle time of scraper}}$

* Working time in minutes/hr.

To calculate the cycle time:

Using performance chart with the input data (Total resistance as a %, weight of loaded scraper to obtain the speed).

Haul Dis.	grade %	R.R %	total (R)	speed	time (min)
loaded scraper					
176860 lb					
1200	+ 4%	+4%	+8%	9mph	$\frac{1200*6o}{9*5280} = 1.515^*$
1400	+ 2%	+4%	+6%	12 mph	$\frac{1400*60}{12*5280} = 1.325$
1400	- 2%	+4%	+2%	32 mph	$\frac{1400*60}{32*5280} = 0.497$

* 1 mile = 5280 ft.

Empty scraper

Using Fig.12 shown below with the input data (Total resistance as a %, weight of empty scraper to obtain the speed).

96880 lb = wt. of empty scraper.

Haul Dis.	grade %	R.R %	T.R	speed	time (min)
1400	+2%	+4%	+6%	23mph	$\frac{1400*60}{23*5280}$ =0.691
1400	-2%	+4%	+2%	32mph	$\frac{1400*60}{32*5280}$ =0.497
1200	-4%	+4%	0	32mph	$\frac{1200*60}{32*5280}$ =0.426

4.951+0.45 fixed time = 5.401 min

$$\text{No. of cycle / hr.} = \frac{50^*}{\text{Cycle time of scraper}} = 9.257$$

$$\therefore \ \underline{production = 25.8 \times 9.2 = 238.83\ cyd\ per\ hr. \quad bank\ measure}$$

Number of scrapers served by a push dozer:-

When using dozer or tractor to push scraper it is desirable to match the number of pushers with the number of scrapers. If a pusher or a scraper must wait for the other, it reduces the operating efficiency of the waiting unit and the project and results in an increased production cost.

To determine the number of scrapers that a dozer or tractor may serve we use the formula below:-

$$\mathbf{N} = \frac{\boldsymbol{Ts}}{\boldsymbol{Tp}}$$

Where:

N= number of scrapers served.

Ts = cycle time for scraper.

Tp = cycle time for pusher dozer or tractor.