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GUIDELINES
ON
DOZERS FOR HIGHWAY WORKS

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GUIDELINES ON DOZERS FOR HIGHWAY WORKS

1. INtRODUCtION

The highway sector in India is poised for fast development. Mechanization in the highway sector has seen a steady growth for the past two decades. It helps in achieving economy, speed and quality in highway construction and maintenance so that roads are built at an accelerated pace as per better standards and specifications. The aim is to avoid not only time and cost overruns but also to derive quick return on investment and early availability of better facility to road users.

Earthwork is one of the significant and basic operations of almost all highway projects. The main task of any highway engineer is to select and match earthmoving machinery to the specific needs of each particular project. There are various stages of earthwork for which appropriate machinery is available.

One such earthmoving equipment is a dozer. It can perform a large number of functions depending on the attachment fixed to the basic machine. It is also a key equipment for disaster mitigation activity pertaining to natural calamities like earthquakes, landslides, floods, tsunami, cyclone outbursts etc.

The initial draft document *"Guidelines on Dozers for Highway Works"* was prepared by Shri Niranjan Kumar Nayak and Shri Ananyabrata Maulik. Necessary inputs were obtained from the Representatives of Industry and incorporated in the document. The Mechanization and Instrumentation Committee (G-4) deliberated on the draft document in a series of meetings and finally approved the draft document in its meeting held on 12th June, 2017. The document was approved by the General Standards and Specifications Committee (GSS) in its meeting held on 24th June 2017 and thereafter by IRC Council in its 212th meeting held at Udaipur(Rajasthan) from 14th to 15th July, 2017.

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2. SCOPE

This document is intended for use by the highway engineers, field personnel with in road construction agencies and contractors entrusted with the task of road construction and maintenance.

This document covers dozer selection, dozer components, and types of blades, blade operation and performance, dozer attachments, dozer productivity, maintenance schedules as well as tips for safe operation of dozers. Emission norms for dozers have been provided in **Appendix-VI**

3. PURPOSE

3.1. Dozer is a self-contained tractor-power unit with a blade attached to the machine's front. It is the most basic, effective and versatile equipment which is widely used in construction projects and capable of performing variety of operations with attachments to the basic unit. Depending on the type of application, it can be mounted with either a rear-mounted winch or a ripper.

3.2. Dozers are used both as support and as production machines in construction projects. Some of the basic functions are listed below:

i) Clear land of timber, stumps and root mat etc. at site of work.

ii) Prepare pilot road/roads through mountains, rocky terrain and hard ground.

iii) Excavate earth or rock for a short haul distance up to say 100 m.

iv) Spreading earth or rock fills and leveling of land.

v) Backfilling the trenches.

vi) Clearing the floor of borrow, quarry pits and construction sites.

vii) Maintaining haul roads.

A detailed description of dozer applications is given in **Appendix-I.**

4. DOZER CLASSIFICAtION

4.1 Dozers may be classified into various categories based on the following:

i) Engine Location

ii) Under Carriage

iii) Nature of Blades

iv) Mode of Power Transmission

v) Job Application

4.2 Based on engine location, dozers may be classified as front engine type **(Fig. 1)** or rear engine type **(Fig. 2)**.

4.3 Dozers may be classified on the basis of undercarriage as:

i) Crawler (track) mounted dozers

ii) Wheel mounted dozers

4.3.1 *Advantages of Crawler mounted dozer:*

a) Ability to deliver more tractive effort, hence can operate on soft footing e.g. loose or muddy soil.

b) More compact and powerful, hence can handle difficult jobs over almost any terrain.

c) Greater flotation because of lower ground pressure.

d) Ability to travel over rocky and rough surface, which reduces cost of maintenance unlike damage of tires in case of wheeled dozer.

e) Can push large blade loads, handle tight soil easily and good for short work distance.

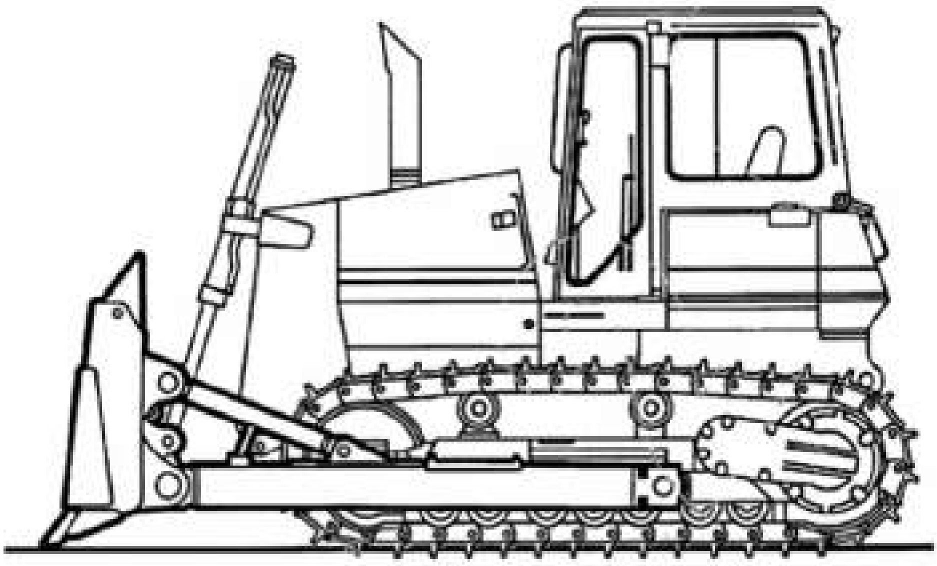

Fig. 1: Crawler mounted Dozer (Front Engine t ype)

4.3.2 *Advantages of Wheel mounted dozers:*

a) Can travel at higher speeds during operation and can shift quickly from one job to another.

b) Good on firm soils, concrete and abrasive soils that have no sharp edged pieces.

c) Can travel on paved roads without damaging them.

d) Ease in operation, hence less operator fatigue.

e) Can travel long distances on its own (unlike crawler type which needs hauling equipment to transport).

f) Capable of producing more output where work is spread over long distance.

g) Operation, maintenance & repair costs are lower as compared to crawler type dozers.

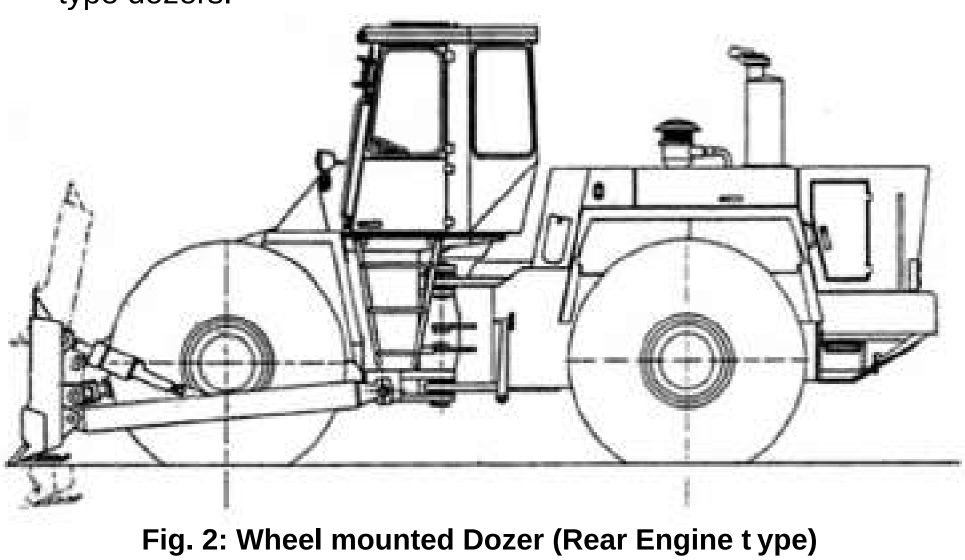

Fig. 2: Wheel mounted Dozer (Rear Engine t ype)

4.4 Dozers may be classified on the basis of nature of blades as:

i) Straight or Straight-tilt dozer

In this type of dozer, the blade is fixed perpendicular to the direction of travel. It moves the earth in forward direction.

ii) Angle dozer

In this type of dozer, in addition to the Straight travel as mentioned above, the blade can also be fixed at an angle to the direction of travel. It can move the earth LH/RH side in forward direction.

4.5 Dozers may be classified on the basis of power transmission as:

i) Direct drive
ii) Torque flow drive
iii) Hydrostatic Transmission (HST)
iv) Hydromechanical Transmission (HMT)

4.5.1 *Direct Drive*

It is basically manual, mechanical type of transmission. A mechanical element (friction clutch) connects the engine to the transmission. The transmission ratio is achieved by a gearing system, where the gearing arrangement may be sliding mesh or constant mesh type. The term 'direct drive' derives its name from the fact that power, in case of highest gear, is transmitted straight through the transmission as if there were a single shaft. In all other gears, mechanical elements match speed and torque **(Fig. 3)**.

Direct drive dozers are best suited for work involving constant loading conditions. A job where full blade loads must be pushed over long distances would be an appropriate application of a direct drive machine.

For direct drive dozers, some manufacturers specify two sets of drawbar pulls- Rated and Maximum. Rated value is the drawbar pull that can be sustained for continuous operation. Maximum value is the drawbar pull that the dozer can exert for a short period while lugging the engine, such as when passing over a soft spot in the ground that requires higher tractive effort over a short period of time.

t able 1: Advantages and Disadvantages of Direct Drive

Advantages	Disadvantages
❒ Power transmission efficiency is high	❒ Gear shifting is complicated ❒ Engine stalls when overloaded ❒ Power transmission is interrupted when shifting gears. ❒ Engine output fluctuates according to load.

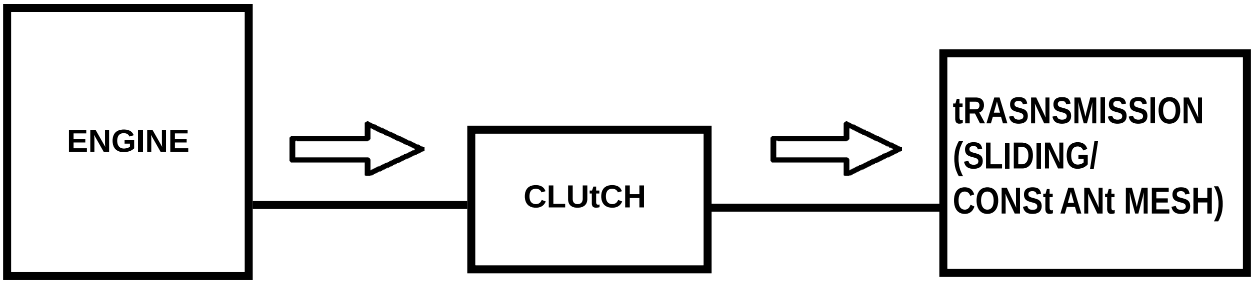

Fig. 3: Direct Drive

4.5.2. *Torque Flow Drive or Hydrodynamic Transmission*

It falls in the category of power shift transmission, that is, shifting of power takes place without the interruption of drive. In torque flow drive, a fluid coupling or torque converter connects the engine to the transmission. Power transmission takes place on account of kinetic energy of fluid **(Fig. 4)**.

The torque converter transmits and decouples the engine power to the gearing system, thereby allowing the machine to stop with the engine still running without stalling. It provides a variable amount of torque multiplication at low engine speeds, increasing breakaway acceleration.

t able 2: Advantages and Disadvantages of t orque Flow Drive

Advantages	Disadvantages
❒ Gear shifting operation is easy ❒ Preferable for applications where load variation is high. ❒ Engine does not stall even when overloaded ❒ No interruption of power transmission when shifting gears	❒ Power transmission efficiency is lower than direct drive machine ❒ More expensive than direct drive machine

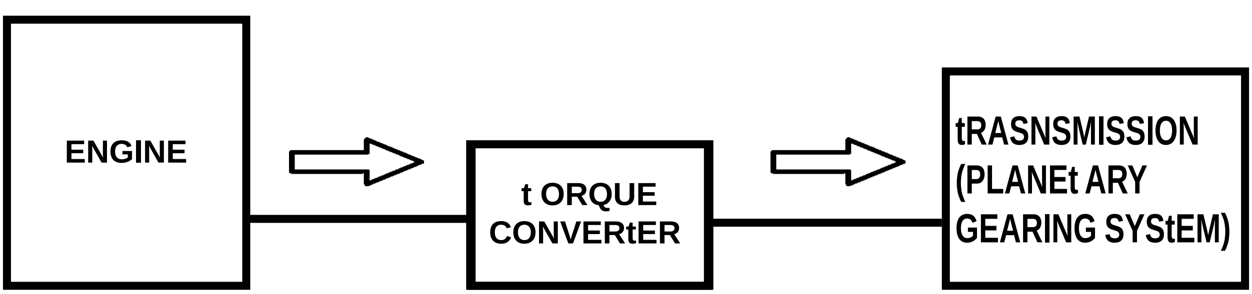

Fig. 4: t orque Flow Drive

4.5.3 *Hydrostatic Transmission (HST)*

Instead of using gears and shaft for transmitting power, hydrostatic transmission **(Fig. 5)** uses a hydraulic circuit comprising of a positive displacement pump and a positive displacement motor to move pressurized fluid (hydraulic oil) through a system of fluids. Usually, the pump is of variable flow type and the motor of fixed flow type. Power transmission takes place on account of pressure energy of fluid.

Rotary power from engine is converted into hydraulic power by the pump connected directly to the engine crankshaft. Motor then converts the hydraulic power back to mechanical rotary power that is further transmitted to the drive wheels/tracks. The speed/torque ratios are controlled by varying the pump discharge with the help of swash plates, which in turn varies the speed of the connected motor.

t able 3: Advantages and Disadvantages of Hydrostatic t ransmission

Advantages	Disadvantages
❒ Gear shifting is not required (stepless speed change) ❒ Engine does not stall even when over-loaded ❒ Operates over a wide range of speed/ torque ratios ❒ No interruption in power transmission during shifting ❒ Improved machine maneuverability ❒ Dynamic braking ❒ Higher efficiency over a wide range of speeds compared to hydrodynamic transmission	❒ Maintenance cost is comparatively high ❒ Skilled manpower is required for maintenance ❒ Power transmission efficiency is lower than that achieved with a discrete gear transmission ❒ Torque ratio is lower than hydrodynamic transmission for different speed ratios.

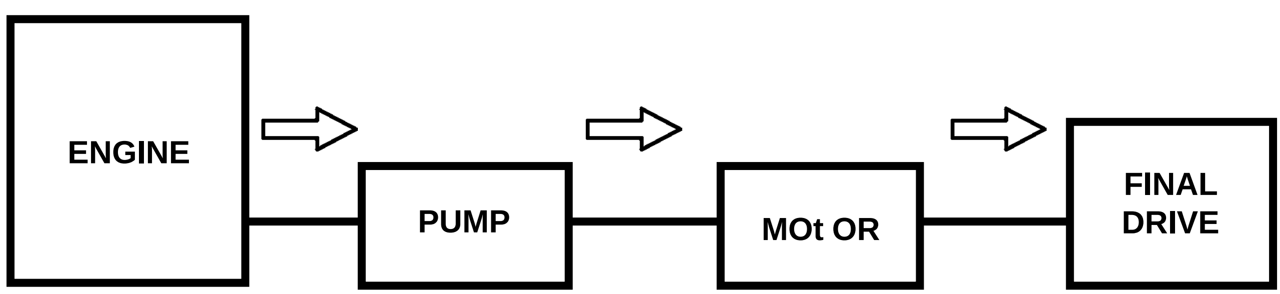

Fig. 5: Hydrostatic t ransmission

4.5.4 *Hydromechanical Transmission (HMT)*

It is a power split type of transmission. The power path connecting the engine to the final drive has two branches- a mechanical branch consisting of mechanical element(s) and a hydraulic branch consisting of a hydraulic pump and hydraulic motor **(Fig. 6)**. Hydromechanical transmission may be of different types- input coupled, output coupled or compound.

t able 4: Advantages and Disadvantages of Hydromechanical t ransmission

Advantages	Disadvantages
❒ Combines the desirable features of both hydrostatic and mechanical transmission (flexible transmission ratios of hydrostatic transmission and high efficiency of gear box). ❒ Gear shifting is not required (stepless speed change) ❒ Higher power transmission efficiency than hydrostatic transmission. ❒ Engine does not stall even when overloaded	❒ Complexity is more ❒ High maintenance cost

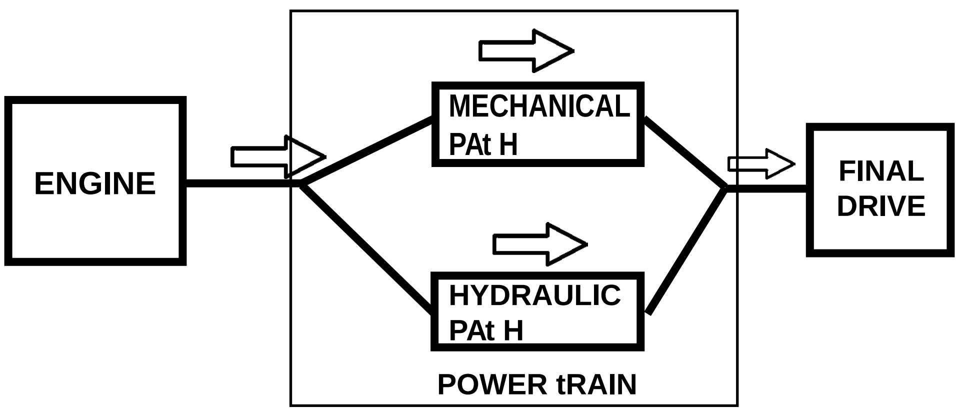

Fig. 6: Hydromechanical t ransmission

4.6. With reference to application in the road sector, dozers may be classified on the basis of engine power and operating weight as given in **t able 5**.

Table 5: Dozer Classification based on Engine Power

Sl. No.	Dozer Class	Engine Power (Gross KW or HP)
1	Light Duty	52 ≤ KW < 75 (70 ≤ HP < 100)
2	Medium Duty	75≤ KW < 104 (100 ≤ HP < 140)
3	Heavy Duty	KW > 104 (HP > 140)

5. DOZER COMPONENtS

The major components of a typical dozer **(Fig. 7)** are as follows:

5.1 Engine

A diesel engine is generally used as a prime mover. It is mounted on the dozer frame.

5.2 t ransmission System

The Transmission system facilitates transmission of power from the engine to the final drive at a multiplicity of speed and torque ratios depending upon load. It may be manual, semi-automatic or automatic type.

5.3 Ground Drive or Final Drive

The power from the transmission is given to the drive axle. The power from the drive axle is transmitted to the wheels and sprockets in wheeled dozers and crawler dozers respectively.

In case of wheeled dozers, the tread of the tire should be selected carefully as it greatly affects its tractive effort on a particular type of soil where it operates.

In crawler dozers, live axles rotate large toothed wheels, known as drive sprockets, located at the rear of the track frame (discussed in Section 5.4)

5.4 Under Carriage

Under carriage is applicable for crawler dozers only. The under carriage components of the dozer are subject to high impact load, severe wear condition due to riding over metal to metal, working in mud, hard gravel and hard stone. In order to meet these requirements, under carriage components are manufactured with wear resistant materials.

An under carriage consists of:

i) Track frame
ii) Equalizer bar
iii) Sprocket
iv) Front idler
v) Track (Bottom) Rollers
vi) Carrier (Top) Rollers
vii) Track chain assembly
viii) Track Adjuster (Grease Cylinder, Recoil Springs etc.)
ix) Guards

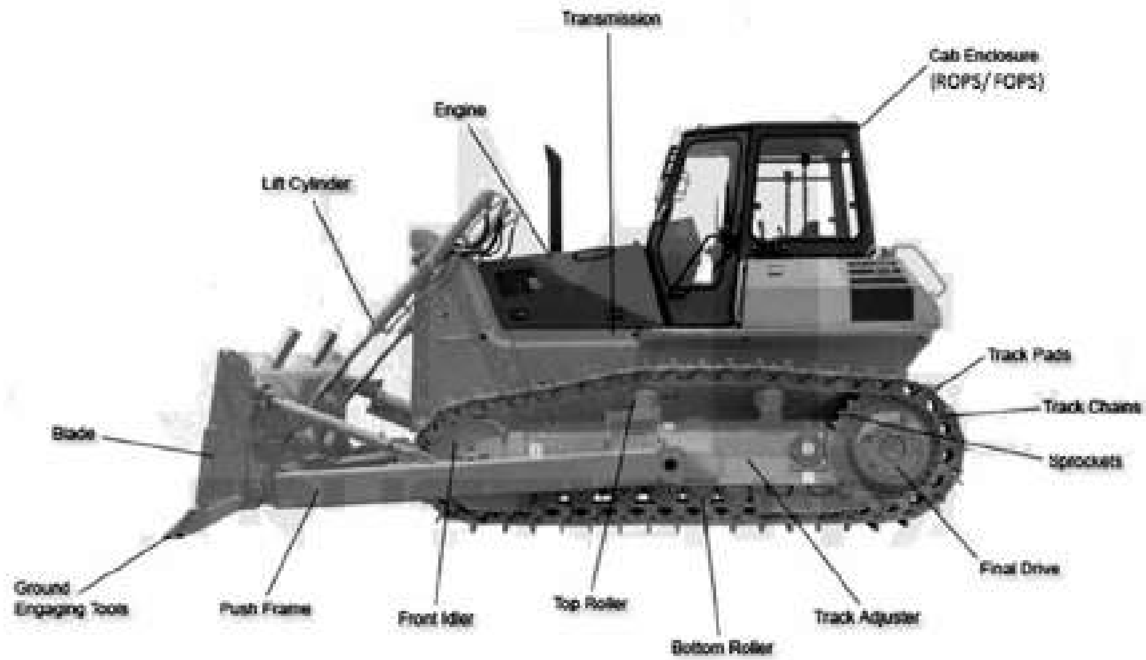

Fig. 7: t ypical Components of a Crawler Dozer

5.4.1 *Track frame*

It acts as a support frame on which various components are mounted. It is fabricated with steel plates by welding and is designed to withstand severe shock loads, bending, deformation and breakage. Track frame vibrations during travel are absorbed by the rubber pads (for improved machine life and operator comfort).

5.4.2 *Equalizer bar*

It is made out of a steel box section beam or a casting beam which distributes the weight of front portion of the machine equally to the two track frames. Its center point is pivoted to the cross bar of the chassis.

5.4.3 *Sprocket*

Sprocket drives the endless track chain to transmit the power for movement of the dozer. Sprocket is either of integral design or segmental design.

5.4.4 *Front Idler*

It supports the front end part of the track chain to allow the track to roll straight over rough ground. It slides at the front end of the frame between the guide plates and connected to the recoil spring assembly through yoke to maintain the desired track tension to keep sufficient engagement of the Track Rollers with the track.

5.4.5 *Track Rollers*

These are mounted under each track frame and bolted on to it. They evenly distribute the weight of the machine on the track and the track links ride on the tread surface of the Track Rollers.

5.4.6 *Carrier Rollers*

They are mounted on to the upper side of the track frame over a support. It guides and supports the upper half of the track chain.

5.4.7 *Track Chain Assembly*

Track chain assembly is formed by assembling track links, pins, seals, bushings and track shoes using bolts and nuts.

5.4.8 *Track Roller Guards*

They protect track rollers from being damaged by rocks and debris, and also prevent track from slipping.

5.5 *Blade*

A dozer blade consists of a mould board with replaceable cutting edges and side (end) bits. Push Frames and Tilt Cylinders or a C-frame and Brace Assemblies connect the blade to the dozer.

6. DOZER BLADES

Blades vary in size and design based on specific work applications. Soil characteristics, moisture content, compaction and terrain will influence the decision of blade selection for optimizing dozer productivity. Using the right blade for a specific job will result in fuel saving, higher productivity and reduced wear and tear.

6.1 Operating Features of Blade

The operating features of the dozer blades may be of three types, which are not applicable to all blades, but any two of these features may be incorporated in a single mount.

i) Tilt **(Fig. 8)**

The design of some machines enables either end of the blade to be raised or lowered in a vertical plane which is termed as Tilt. Tilting enables concentration of dozer driving power on a limited portion of the blade’s length.

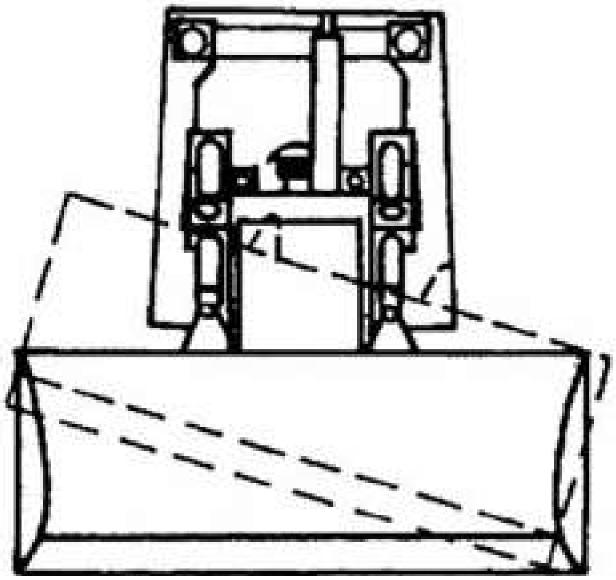

Fig. 8: t ilting of Dozer Blade

ii) Pitch **(Fig. 9)**

The top of the blade can be moved forward or backward varying the angle of attack of the cutting edge, which is termed as Pitch. This is a pivotal movement about the point of connection between the dozer and the blade. When top of the blade is pitched forward, the bottom edge moves back, and this increases the angle of attack of the cutting edge.

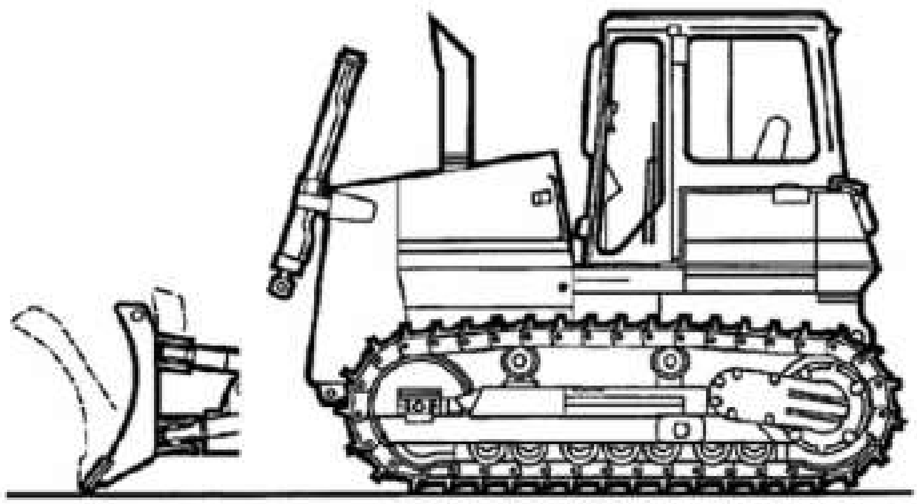

Fig. 9: Pitching of Dozer Blade

iii) Angling **(Fig. 10)**

Blade mounted on a C – frame or a U – frame can be turned from the direction of travel, which is termed as Angling. Angling causes the pushed material to roll off the trailing end of the blade. This procedure of rolling material off one end of the blade is called side casting.

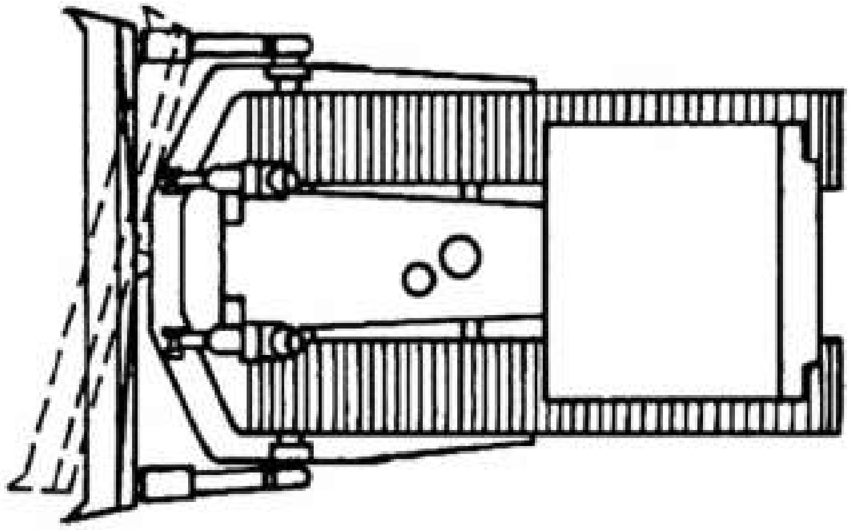

Fig. 10: Angling of Dozer Blade

6.2 Blade Operation

The blade is raised or lowered hydraulically. The pitch, tilt and angling of the blade are controlled hydraulically. Specifications generally indicate the type and capacity of the pump, the relief pressure of the system, and the bore and stroke of the lift, pitch, tilt and/or angling cylinders.

Additionally, basic earthmoving blades are curved in the vertical plane in the shape of a flattened C. When the blade is pushed down, the edge cuts into the earth. As the dozer moves forward, the cut material is pushed up the face of the blade. The upper part of the flattened C rolls this material forward. The total effect is to “boil” the pushed material over and over in front of the blade. The flattened C shape provides the necessary cutting angle for the edge and at the beginning of the pass, the weight of the cut material on the lower half of the C helps achieve edge penetration. As the push progresses, the load in front of the blade passes the midpoint of the C and begins to exert an upward force on the blade. This “floats” the blade reducing the penetration of the cutting edge.

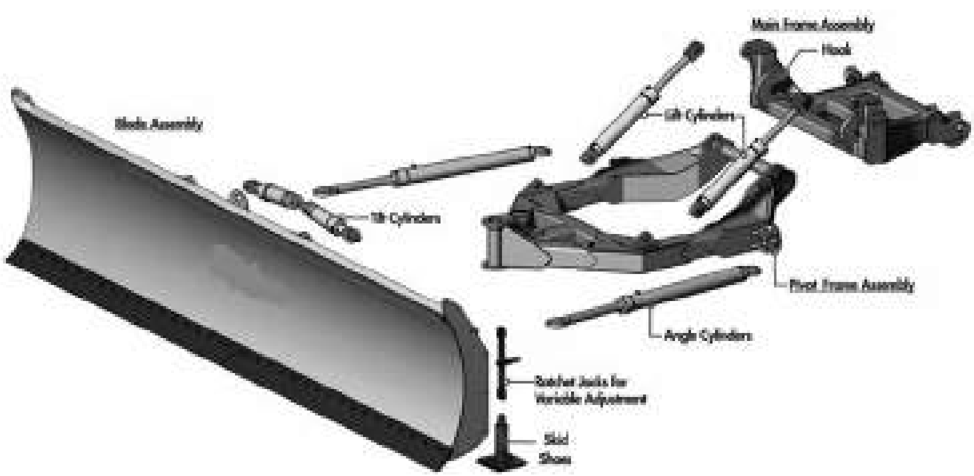

Fig. 11: Typical Configuration of a Blade-Pivot Frame-Main Frame Assembly

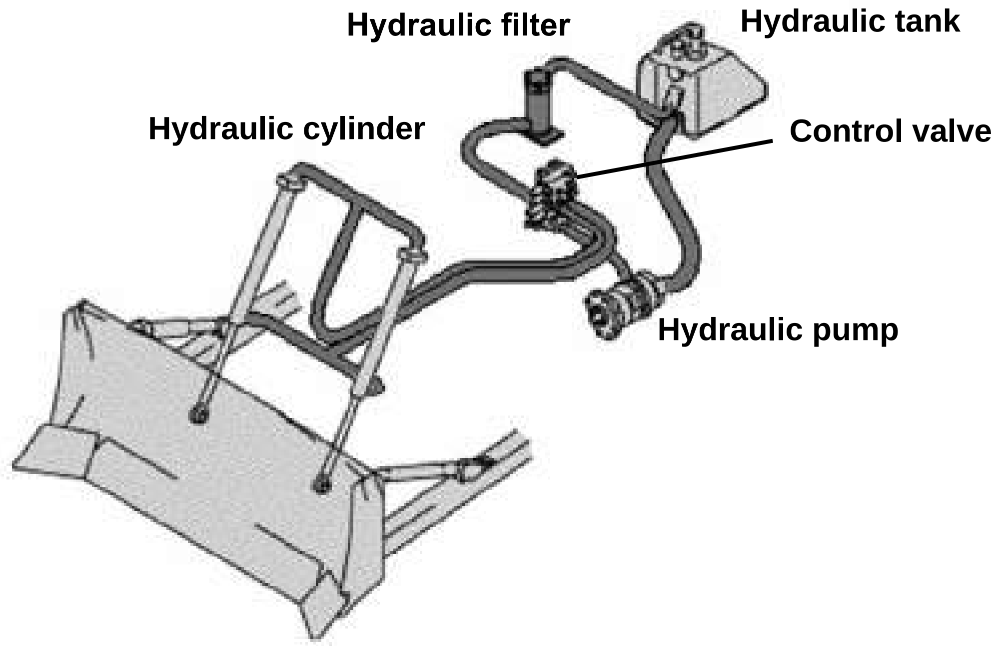

Fig. 12: t ypical Hydraulic Circuit for Blade Operation

6.3 t ypes of Blade

Many different special application blades may be attached to a dozer, but basically the following types of blades are common for application in the highway sector:

i) Straight blade 'S'

ii) Angle blade 'A'

iii) Universal blade 'U'

iv) Semi-U blade 'SU'

v) Cushion blade 'C'

vi) Power, Angle and Tilt Blade 'PAT'

Note: *Other types of blades like K/G Blade, Variable Radius Blade, Rake etc. are also available.*

6.3.1 *Straight Blade 'S'* ***(Fig. 13)***

It is designed for short and medium distance passes such as backfilling, stumping, stripping, shaping, ditching, grading and spreading fill material. It has no curvature along its width and is mounted in a fixed position, perpendicular to the dozer's line of travel. It is attached to the dozer machine by dozer arms at the lower corners of the back of the blade, thereby eliminating the option of angling. The S blade is vertically stabilized with angle braces to the dozer arms that may be outfitted with a hydraulically operated tilt cylinder allowing for horizontal adjustment.

Generally straight blade is a heavy duty blade and can be tilted within a 10°arc, increasing penetration for cutting or decreasing penetration for back dragging. It can be equipped to pitch for enabling the operator for setting the cutting edge to dig hard materials or moving the edge's plane of attack to ease the drifting of light materials.

Given the straight configuration and lack of side wings to hinder material side spillage, the S blade has limited material carrying capabilities. The rugged design, weight and geometry of the blade give it good penetrating characteristics which allow for better dozing of harder materials.

S blade provides excellent versatility. Being physically smaller than the SU or U blade, it is easier to maneuver and can handle a wider range of materials. It has a higher KW/m of cutting edge than the SU or U blade and, therefore, is more aggressive in penetrating and obtaining a blade load.

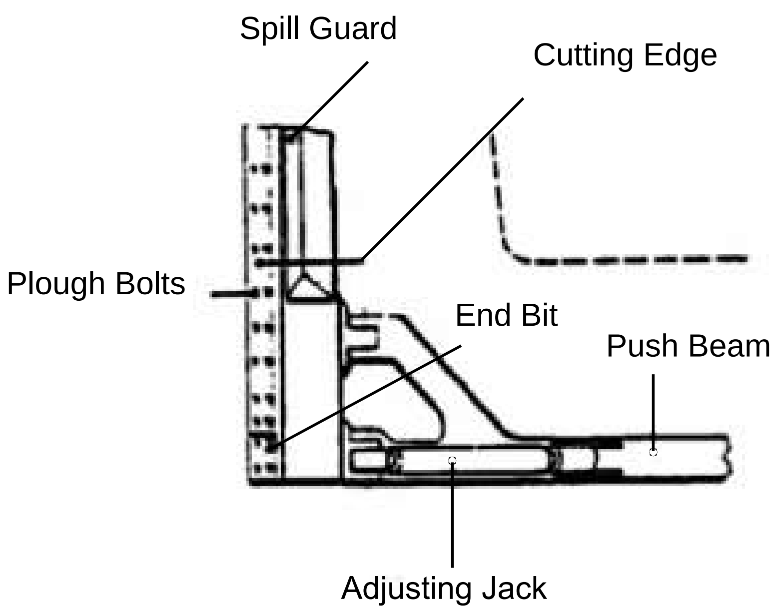

Fig. 13: Straight Blade

6.3.2 *Angle Blade 'A'* ***(Fig. 14)***

An angle blade is wider than 'S' blade. It can be angled up to a maximum of 25° left or right of perpendicular to the dozer or can be used as a straight blade. Since angle blade is attached to the dozer by a C – frame mount, it can be tilted. To facilitate vertical stability of blade, it is provided with either manual screw type tilt adjusters or hydraulically operated tilts on one or both of the side arms.

The angle blade is highly effective for side casting of material particularly for back filling or making side-hill cuts. It can also be used for stumping, stripping, shaping, ditching, trail pioneering and general dozing of medium to softer materials.

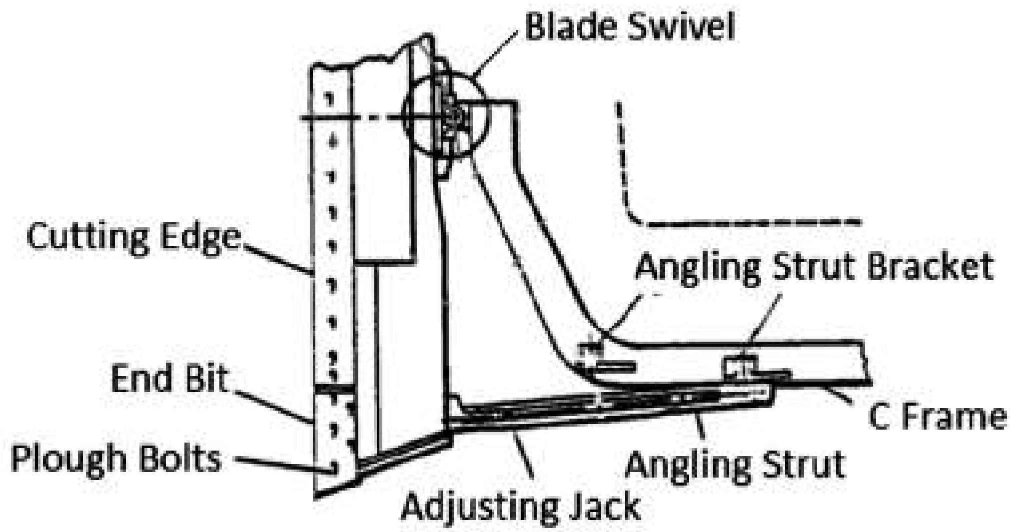

Fig. 14: Angle Blade

6.3.3 *Universal Blade 'U'* ***(Fig. 15)***

This blade is wider than a straight blade and the outside edges are canted forward about 25°. The canting of the edges reduces the spillage of loose material, making the U blade efficient for moving large loads over long distance. It is mounted with heavy dozer arms from trunnions on the sides of the tractor to the lower bottom corners of the blade. The U blade is made vertically stable from the push arms with angle braces that incorporate one or two hydraulic tilt cylinders. The tilt cylinders provide the blade with the ability to concentrate the ground penetrating forces, thereby increasing versatility to include operations such as ditching and crowning.

The KW/m ratio is lower than the S or SU blade mounted on a similar dozer, which indicates that penetration is not a prime objective of this blade. The KW/cum is also lower than the S or SU blade which denotes the blade is best suited for lighter materials. This blade is mainly used for stockpile works, trapping for loaders and land reclamation.

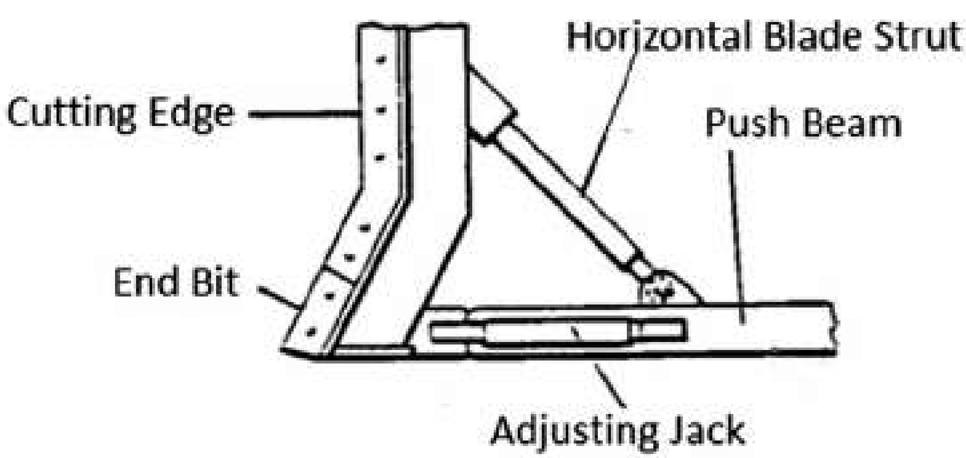

Fig. 15: Universal Blade

6.3.4 *Semi-U Blade 'SU'* ***(Fig. 16)***

Semi-U blade has the combined features of both 'S' and 'U' blade designs. It increases material loading and carrying capacity due to addition of forward curving short wings on either end that work to limit material spillage.

It is mounted to the tractor with heavy straight push arms attached to the lower back of the blade. The blade is made vertically stable from the dozer arms with angle braces which will incorporate one or two hydraulic tilt cylinders. The tilt cylinders provide the ability to alter the horizontal plane of the blade and concentrate ground penetrating forces. This feature increases the blade versatility to include crowning and ditching. It has lower ground penetration ability than S blade.

SU blade is well suited for activities like stumping, stripping, backfilling, ditching, crowning and leveling. It works well in soft to medium hard soils, especially with the skillful application of the tilt feature.

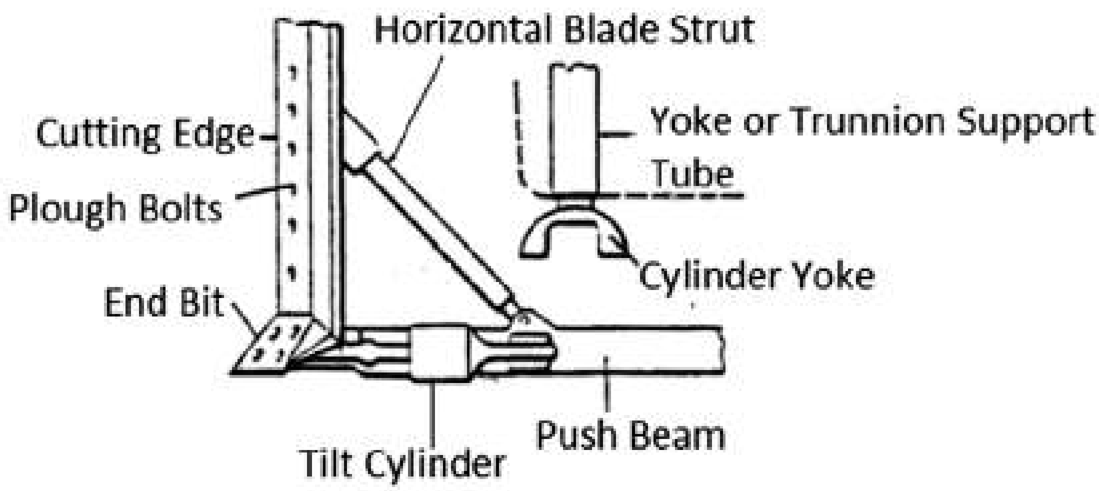

Fig. 16: Semi-U Blade

6.3.5 *Cushion Blade 'C'* ***(Fig. 17)***

Cushion blade is effectively used for pushing the material and not suitable for production dozing purposes. It cannot be tilted, pitched or angled. It is generally mounted on large dozers that are used for push-loading scrapers. This blade is shorter than the S blade which facilitates maneuvering into position behind the scrapers. The use of cushion blade instead of a "pusher block" to push scrapers can clean up the cut area and increase the total fleet production.

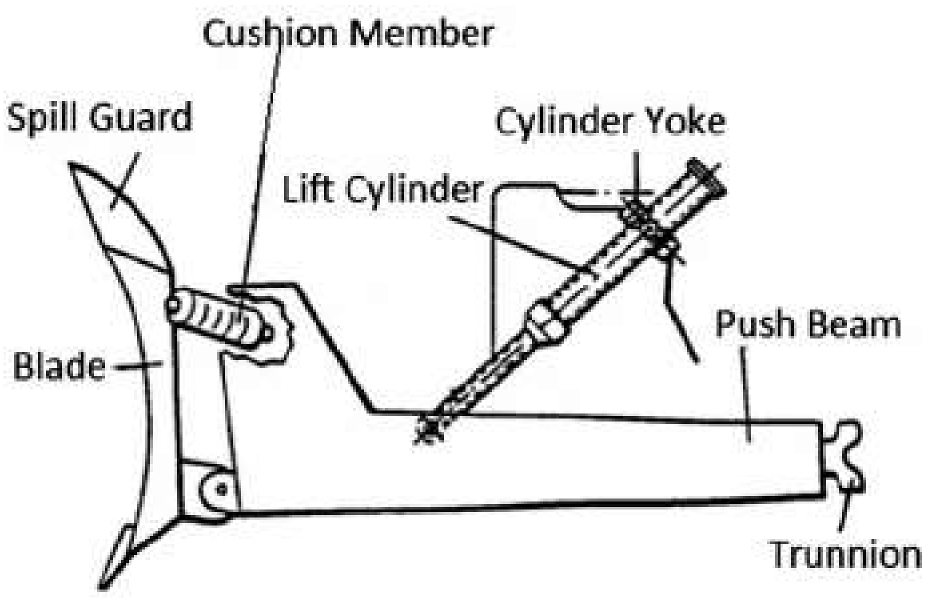

Fig. 17: Cushion Blade

6.3.6 *Power, Angle and Tilt Blade 'PAT'* ***(Fig. 18)***

It is a special type straight blade. Here, it is possible to hydraulically raise, tilt and angle the blade. Applications include grading, backfilling, land clearing, ground leveling and spreading operations.

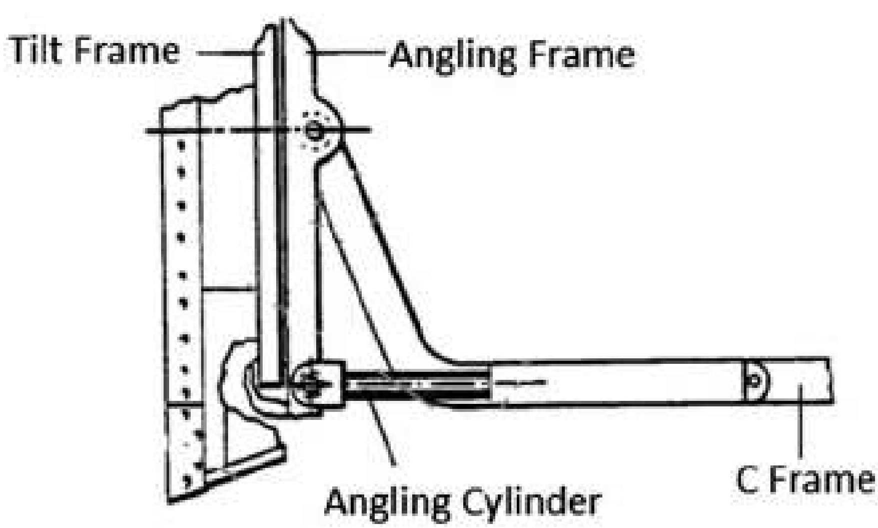

Fig. 18: PAt Blade

6.4 Blade Performance

Performance potential of a dozer is measured by two standard ratios:

i) Kilowatt per metre of cutting edge.

ii) Kilowatt per loose cubic metre of material retained in front of the blade.

6.4.1 Kilowatt per metre (KW/m) provides an indication of the ability of the blade to penetrate and obtain a load. The higher this ratio, the more aggressive the blade is.

6.4.2 The pushing potential of a particular blade is the relationship between available machine Kilowatt and volume of displaced material. Kilowatt per loose cum (KW/cum) provides an indication of the blade's ability to push a load. A higher ratio means that the dozer is more productive.

7. DOZER Att ACHMENtS

The optional attachments usually available for dozer are listed below:

i) Ripper
ii) Winch
iii) Swinging Drawbar

7.1 Ripper (Fig. 19)

Ripper is an optional attachment connected to the rear of the dozer by means of a mounting bracket and is equipped with one or more teeth. It is used to loosen densely compacted materials so that the dozer blade will be able to penetrate and push easily. Rippers are able to penetrate where a blade will simply scrape along.

Today, ripping has become a popular method of excavating soil and rock. It is mostly used to excavate overburden. Cost of ripping should be compared with the cost of drilling and blasting to consider economical way of excavation.

Fig. 19: Dozer with Ripper Attachment

7.1.1 Ripping is preferred over drilling and blasting for the following reasons:

i) Increased productivity due to continuous operation of machine and reduced idle time
ii) Minimized ground vibration
iii) Reduced noise and dust
iv) Better safety and slope stability
v) Involvement of less machinery
vi) Environment friendly

7.1.2 The following types of rippers are used with the dozer as attachment:

i) Radial type **(Fig. 20)**

Here, the ripping angle of the tooth tip to the ground varies according to change in the working depth.

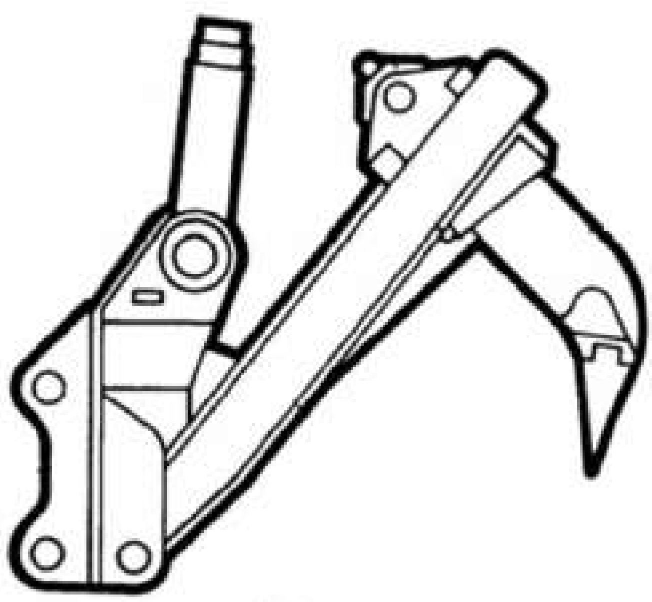

Fig. 20: Radial Ripper

ii) Parallelogram type **(Fig. 21)**

Here, the ripping angle of the tooth tip to the ground remains constant regardless of variations in the working depth.

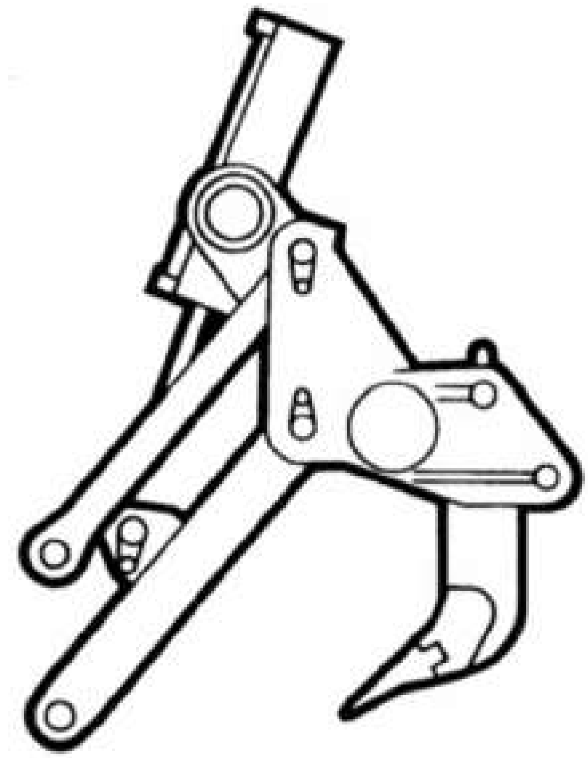

Fig.21: Parallelogram Ripper

iii) Variable type **(Fig. 22)**

Here, the ripping angle of the tooth tip to the ground is variable and can be changed by the operator.

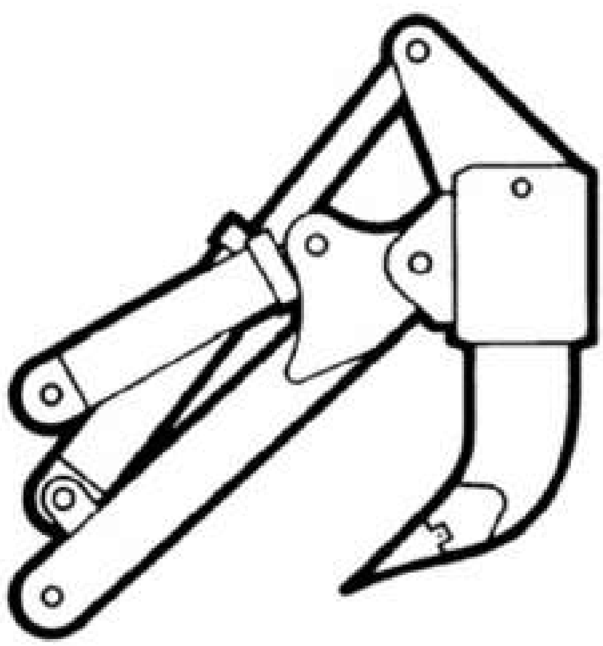

Fig. 22: Variable Ripper

iv) Impact type

It exerts an additional impact force by means of a hydraulic pulsing system.

7.1.3 The various parts of a typical ripper are shown in **Fig. 23.**

The Ripper Point or Tip can be replaced whenever it breaks or wears out, and it protects the shank and adapter from damage. When adapter is breaking frequently, the next shorter tip should be used so as to reduce the load on the adopter. The Protector is provided as an additional protection for the adapter and is replaced when it is worn out.

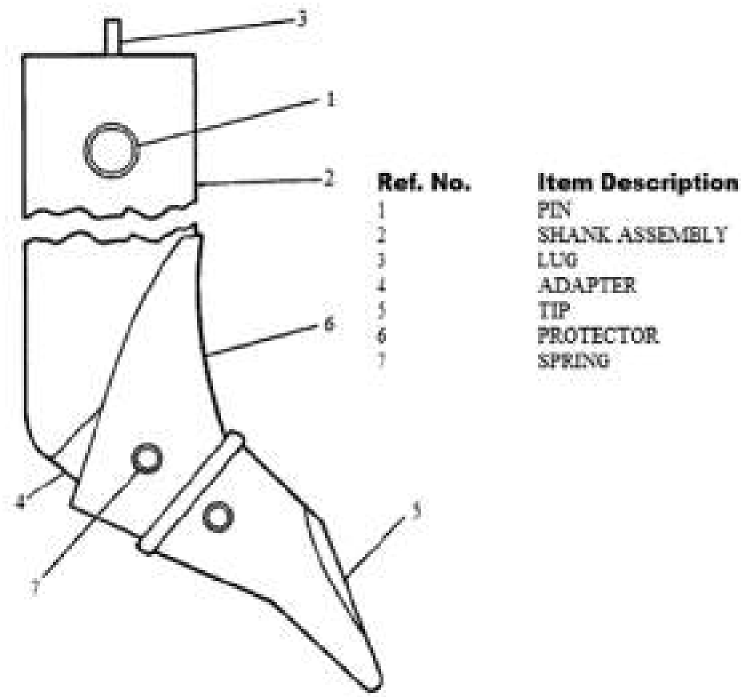

Fig. 23: t ypical Parts of a Ripper

7.1.4 Ripper selection depends on degree of rippability of rock, which is governed by the following factors:

i) Nature and formation of rock (Igneous and metamorphic rocks are difficult to rip in absence of substantial fractures or weak planes while sedimentary rocks are more amenable to ripping due to presence of clear planes of stratification.)

ii) Brittleness and crystalline structure of rock

iii) Degree of stratification and lamination of rock

iv) Well defined fracture plane

v) Moisture content (Presence of moisture reduces the shear strength of rock and makes it suitable for ripping.)

vi) Geological disturbances like faults, joints, fractures and planes of weakness

vii) Grain size (Coarser the grain size, the more suitable it is for ripping.)

viii) Degree of consolidation of rock

ix) Mechanical properties of rocks like compressive strength, tensile strength, shear strength etc.

x) Specific energy

Rippability analysis of a particular site should preferably include geological site survey, field seismic velocity measurements, laboratory analysis of rock properties and an equipment investment analysis in order to facilitate selection of the appropriate ripper.

7.1.4.1 Ripper selection also involves choosing the correct tip configuration as well as the correct style (centerline or penetration). **t able 6** illustrates the recommendations to obtain optimal performance from the ripper.

Table 6: Recommendations for Selection of Tip Configuration of Ripper

Sl. No.	Tip Configuration	Recommended Usage Condition
1	Short	For use in high impact conditions where breakage problems occur. The shorter the tip, the more it resists breakage.
2	Intermediate	For use in moderate impact conditions where abrasion is not excessive.
3	Long	For use in loose, abrasive materials where breakage is not a problem.

7.1.4.2 The material being ripped as well as the dozer will both have an effect on which tip will do the best job. High density material requires a 'penetration' tip whereas high impact material requires a 'centerline' tip.

7.2 Winch (Fig. 24)

A winch is a frame equipped with a drum and connected to the rear of the dozer. Applications include uprooting of trees, skidding of boulders or heavy materials, general/ equipment recovery etc.

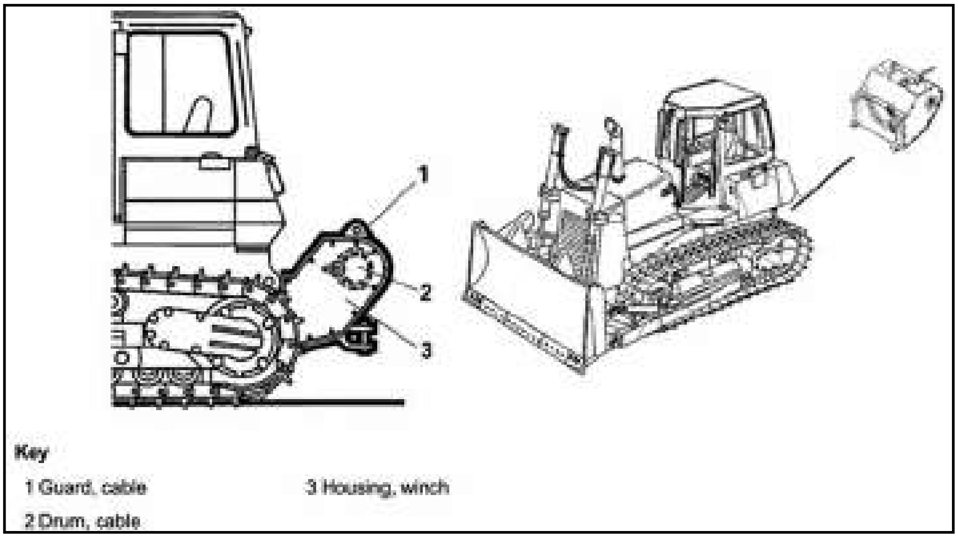

Fig. 24: Dozer with Winch Attachment

7.2.1 There are two types of winch operation:

i) Manually controlled Winch

It is operated by a manually controlled clutch and brake.

ii) Power controlled Winch

It is operated hydraulically or by a power clutch and brake.

7.2.2 Winch performance is determined by maximum line pull and maximum line speed. Line pull is the winch pull force measured at engine rated speed with full drum and bare drum. Line speed is the winch speed measured at engine rated speed with full drum and bare drum.

7.3 Swinging Drawbar (Fig. 25)

It is a frame, equipped with a swing selector bar and a drawbar, and is connected to the rear of the dozer. It is used for haulage purpose and its performance is determined by the maximum drawbar pull of the dozer.

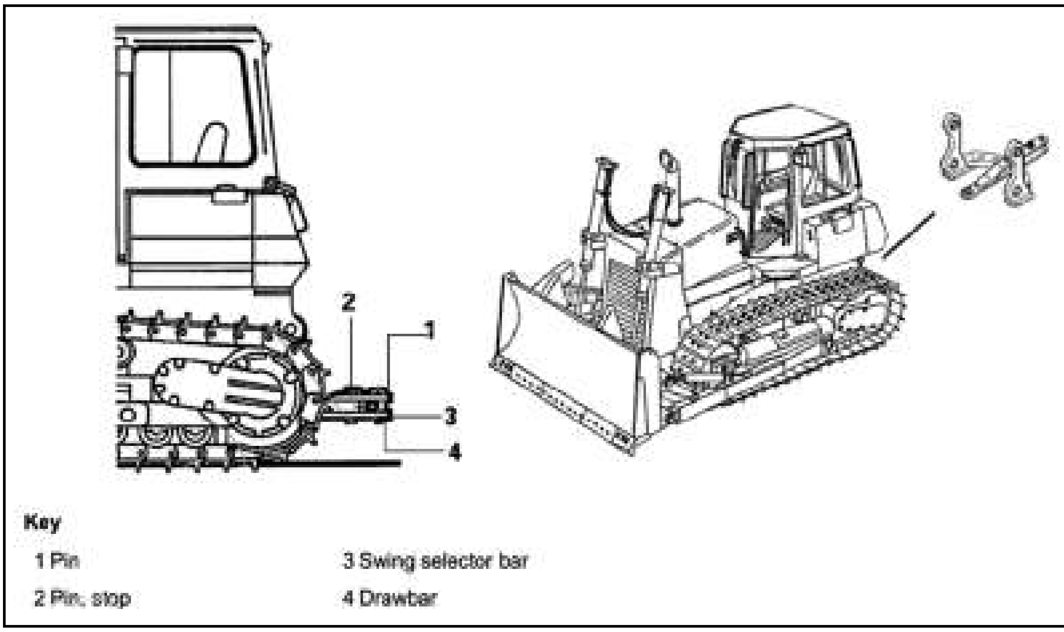

Fig. 25: Dozer with Swinging Drawbar Attachment

8. DOZER PERFORMANCE

Blade selection is not the sole criterion for maximizing production. Dozer limitations based on traction, rolling resistance, grade resistance of work site etc. need to be kept in mind at the time of dozer selection to ensure that the blade and the machine are compatible for the particular job at hand. The weight and engine power of the dozer determine its ability to push.

The primary objective while selecting a dozer is to identify the kind of work it will be doing most of its life because dozer performance will vary with the material characteristics as illustrated in **t able 7**.

t able 7: Effect of Material Characteristics on Dozer Performance

Sl. No.	Material Characteristics	Remarks
1	Material Size and shape	The larger the individual material (particle) size, the harder it is for a cutting edge to penetrate. Materials with sharp edges resist the natural rolling action of dozer blade. These materials require more engine power to move than a similar volume of material with rounded edges.
2	Voids	Few voids or the absence of voids means the individual particles have most or all of their surface area in contact with other particles. This results in a stronger bond and thus greater engine power is required to move such material.
3	Moisture Content	The lower the moisture content of the material, the greater is the bond between particles and thus greater engine power is required to move such material.

The following parameters help in performance evaluation of a dozer with respect to its weight and engine power:

8.1 Net Power

It is the power obtained on a test bed at the end of the crankshaft or its equivalent, at the corresponding engine speed (refer to **ISO 9249:2007**).

8.2 Maximum t ravel Speed

It is the maximum speed that can be obtained on a hard level surface in each of the forward and reverse gear ratios available with the machine at its operating mass, as determined in accordance with ISO 6014.

8.3 t ractive Effort

The tractive effort is the usable force available to perform work and is limited by the following two factors:

i) Weight carried by the drive wheels
ii) Coefficient of traction of the surface being traversed

Dozer weight is important in many projects because the maximum tractive effort that a unit can provide is limited by the product of the weight times the coefficient of traction for the unit and the particular ground surface, regardless of the power of the engine.

The crawler dozer is designed for jobs requiring high tractive effort.

In case of wheeled dozers, the coefficient of traction between rubber tires and soil surfaces is lower and, therefore, the wheel tractor may slip before developing its rated pulling effort. In order to attain higher speed, a wheeled dozer must sacrifice pulling effort.

Traction or floatation requirements can be met by proper under carriage or tire selection.

For a dozer operating at a given engine power, the available tractive effort decreases as its travel speed increases.

8.4 Drawbar Pull

The available pull that a dozer can exert on a load that is being towed is referred to as its drawbar pull. It depends on the effect of grade resistance and rolling resistance at the work site and is equal to the difference between the tractive effort available and tractive effort required to overcome these effects.

Rolling resistance is primarily due to tire flexing and penetration of the travel surface, whereas grade resistance represents that component of vehicle weight which acts parallel to an inclined surface. For uphill movement along an inclined surface, grade resistance is positive, and, for downhill movement, it is negative.

Drawbar Pull varies inversely with the speed of each gear. It is highest in the first gear and lowest in the top gear. **Fig. 26** shows the typical variation of drawbar pull of a dozer with its speed.

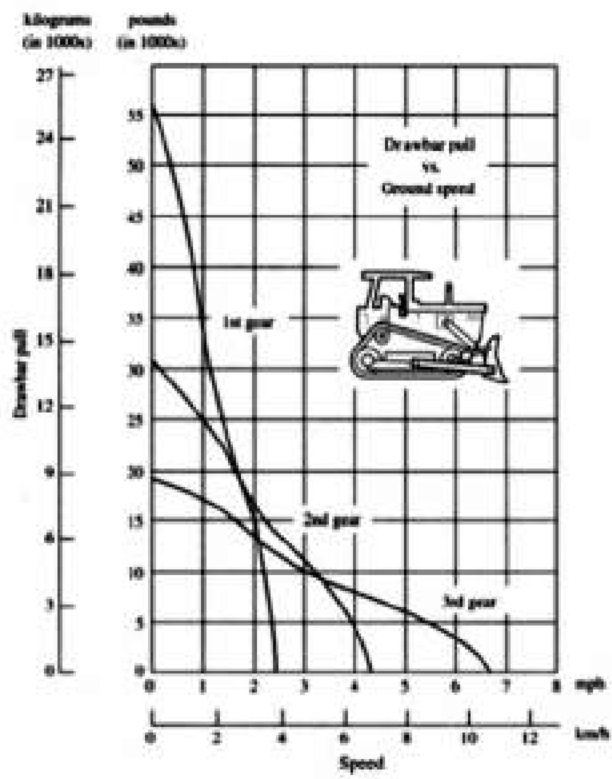

Fig. 26: t ypical Drawbar Pull Performance Chart of a Crawler Dozer

Note: *The term 'Drawbar Pull' is normally used in case of crawler dozers only. For wheeled dozers, the term 'Rimpull' is used.*

8.5 Static Slope Capacity

It is the maximum slope, expressed in degrees, that the machine fluid system(s) can operate on without malfunction or damage of any fluid system, at all machine orientations- longitudinal or lateral, in accordance with **ISO 10266:1992**.

It will be higher for a dozer with no load compared to that with load.

9. DOZER PRODUCtIVItY

9.1 Dozer operation essentially comprises of a series of cyclic operations or cycles. Standard hourly production is the amount of material removed per hour and may be estimated as follows:

$$Q = (A \times 60 \times E)/ C_m$$

Where,

Q = Standard hourly production of dozer in cubic metres,

A = Production per cycle in cubic metres,

E = Correction Factor,

C_m = Mean cycle time in minutes

9.2 Production per cycle (A) in cubic metres for dozer may be estimated as:

$$A = F_B \times W \times H^2$$

Where,

F_B = Blade Factor,

W = Width of blade (exclusive of end bits) in metres,

H = Effective Height of blade in metres

Value of blade factor will depend upon the type of blade as follows:

t able 8: Blade Factor Values for Various Blade t ypes

t ype of Blade	Blade Factor
Angle Blade, Straight Blade, Semi-U Blade	0.81
U Blade	0.87

9.3 Mean cycle time for a dozer is composed of two components- fixed time and variable time. Variable time is the time spent on travelling and is a function of the distance travelled as well as speed of the dozer. Speed of travel depends on several job factors like rolling resistance, grade resistance, altitude and power rating of the dozer. Fixed time is the time spent in the performance of all operations other than travelling, such as loading, dumping, turning, gear shifting, etc.

9.3.1 Mean cycle time (in minutes) for dozer may be calculated as follows:

$$C_m = (D_t/V_t) + (D_r/V_r) + t_t$$

Where,

D_t = Travel distance in metres,

D_r = Return distance in metres,

V_t = Travel speed (during pushing load) in metres/minute,

V_r = Travel speed (during return) in metres/minute,

t_t = Fixed time in minutes

9.3.2 Speeds for a dozer in operation will generally range from 3 to 5 km/hr for forward motion and 5 to 7 km/hr for reverse motion. Actual speeds shall however be selected based on manufacturer's specifications. In case of dozers fitted with torque converters, actual speeds may be calculated as given below:

Travel speed = Maximum speed x 0.75

Return speed = Maximum speed x 0.85

9.3.3 Fixed time for a dozer includes the time required for gear shifts, which may be taken as follows [as per IS 11399:Part-I:1985].:

t able 9: Gear Shifting t ime for Various Drives

Sl. No.	t ype of Drive	t ime for Gear Shifting, in minutes
1	Direct Drive:	
	Single lever	0.1
	Two levers	0.2
2	Power shift	0.05

9.4 Correction factor (E) may be calculated as follows:

E = E1 x E2

where,

E1 = Time efficiency

E2 = Working efficiency or Job and Management Factor

9.4.1 *Time Efficiency (E1)*

Dozer is never operated all the 60 minutes in an hour. A value of 45-50 min/hr will be appropriate for day operation and 40-45 min/hr for night operation. The cycle time will therefore, need to be corrected taking this aspect into consideration. For instance, assuming dozer operation for only 50 minutes every hour, the time efficiency works out to 0.83.

9.4.2 *Working Efficiency (E2)*

Dozer output is also affected by job and management factors. The job factors which are inherent in the job itself relate to site topography, available working space, climatic conditions, geology of the area affecting method of dozing, specification of work etc. Management factors pertain to efficiency of the organization and operating staff, appropriateness of the equipment for the job, job planning, supervision, maintenance of the equipment etc. It is on the management aspects that the Site Engineer should apply all his efforts for improving the efficiency and productivity of dozer operation. For estimation of standard production of dozers, the following values for working efficiency are recommended [as per IS: 11399 (Part-I), 1985].

Table 10: Working Efficiency Values for Various Job and Management Conditions

Job Conditions	Management Conditions			
	Excellent	Good	Fair	Poor
Excellent	0.84	0.81	0.76	0.70
Good	0.78	0.75	0.71	0.65
Fair	0.72	0.69	0.65	0.60
Poor	0.63	0.61	0.57	0.52

9.5 It may be noted that the volume of material in standard production (Section 9.1) pertains to soil in loose condition. Dozer output is generally expressed in terms of ‘bank measure’, which is a measure of the soil in-situ. Dozing/excavation of a given weight of material causes its volume to increase due to air pockets and voids and it is in this loose state that the equipment has to move the material.

Therefore, the net hourly production of a dozer (Q_n), expressed in cubic metres of ‘bank measure’, may be calculated as:

$$Q_n = Q \times LF$$

where,

Q = Standard hourly production in cubic metres,

LF = Load Factor

Load factor may vary from 0.5(50% voids) to 0.95(5% voids) depending on the material characteristics and its condition (voids) in-situ.

10. DOZER MAINtENANCE

Dozer is expensive as well as critical equipment for all highway projects which is meant for heavy duty applications and operated often under severe operating conditions. It is therefore imperative that proper maintenance of dozer is ensured for its trouble free operation as repair after failure can be 10 to 15 times more expensive than repair before failure. Failure to adhere to proper maintenance intervals and procedures may result in diminished performance of the machine and/or accelerated wear of components.

The success of an effective maintenance strategy lies in properly timing the replacement and overhaul of individual components so that they do not waste the residual life of the machine as a whole since individual life span of the components is less than the machine life. Dozers that operate in severe operating conditions may require frequent maintenance. Maintenance intervals have to be determined depending upon factors like number of working hours, load factor, equipment age, intuition and experience with the equipment, site condition, environmental factors etc., using suitable parameters for purpose of calculation of interval like fuel consumption, service hours, or calendar time, whichever occurs first.

10.1 Daily Maintenance Schedule (or Every 10 Service Hours)

i) Testing of backup alarm
ii) Checking of cooling system coolant level
iii) Inspection and/or replacement of cutting edges and end bits
iv) Checking of engine oil level
v) Checking of hydraulic system oil level (steering and brake)
vi) Checking of oil renewal system oil level
vii) Inspection of seat belt
viii) Checking of transmission oil level

10.2 Weekly Maintenance Schedule (or Every 50 Service Hours)

i) Cleaning and/or replacement of cab air filter
ii) Draining of fuel tank water and sediment
iii) Checking of tire inflation

10.3 Initial 250 Service Hours

i) Checking of engine valve lash
ii) Inspection of engine valve rotators
iii) Replacement of transmission oil filter

10.4 Monthly Maintenance Schedule (or Every 250 Service Hours)

i) Lubrication of axle oscillation bearings
ii) Cleaning of battery
iii) Inspection, adjustment and/or replacement of belts
iv) Testing of braking system
v) Checking of differential and final drive oil level
vi) Changing of engine oil (high speed) and oil filter
vii) Obtaining engine oil sample
viii) Changing of engine oil and filter
ix) Lubrication of steering cylinder bearings

10.5 Initial 500 Service Hours

i) Adjustment of seat side rails

10.6 Quarterly Maintenance Schedule (or 500 Service Hours)

i) Obtaining cooling system coolant sample
ii) Obtaining differential and final drive oil sample
iii) Lubrication of drive shaft spline (center)
iv) Cleaning of engine crankcase breather
v) Cleaning and/or replacement of fuel system primary filter
vi) Replacement of fuel system secondary filter
vii) Cleaning of fuel tank cap and strainer
viii) Replacement of hydraulic fan valve screen
ix) Replacement of hydraulic system oil filter (Implement Pilot)
x) Replacement of hydraulic system oil filter (Steering Pilot)
xi) Obtaining hydraulic system oil sample (Implement and Hydraulic Fan)
xii) Obtaining hydraulic system oil sample (Steering and Brake)
xiii) Replacement of transmission oil filter
xiv) Obtaining transmission oil sample

10.7 Bi-Annual Maintenance Schedule (or Every 1000 Service Hours)

i) Lubrication of articulation bearings
ii) Tightening of battery hold-down
iii) Lubrication of drive shaft support bearing
iv) Lubrication of lift cylinder yoke bearings
v) Inspection of ROPS (Roll over Protective Structures)
vi) Lubrication of tilt cylinder bearings
vii) Changing of transmission oil

10.8 Annual Maintenance Schedule (or Every 2000 Service Hours)

i) Checking of brake accumulator
ii) Obtaining cooling system coolant sample
iii) Changing of differential and final drive oil
iv) Inspection and/or adjustment of electronic unit injector
v) Changing of hydraulic system oil (Implement and Hydraulic Fan)
vi) Changing of hydraulic system oil (Steering and Brake)
vii) Checking of hydraulic system oil level (Implement and Hydraulic Fan)
viii) Cleaning of hydraulic tank breaker relief valve
ix) Replacement of refrigerant dryer

10.9 Every 2 Years or 3000 Service Hours

i) Inspection of crankshaft vibration damper

ii) Inspection of engine mounts

10.10 Every 2.5 Years or 4000 Service Hours

i) Checking of engine valve lash

ii) Inspection of engine valve rotators

10.11 Every 3 Years or 5000 Service Hours

i) Replacement of seat belt

ii) Inspection of alternator

iii) Inspection of starting motor

iv) Inspection of turbocharger

v) Changing of cooling system coolant

vi) Inspection of engine water pump

vii) Replacement of VIMS module battery

10.12 Every 6 Years or 12000 Service Hours

i) Replacement of cooling system water temperature regulator

ii) Cleaning, inspection, rebuilding and /or installation of engine components

11. DOZER SAFEtY

Since dozers are bulky and are designed to move large amounts of earthwork and other construction material with each push, they can result in serious injury or even death, if not operated properly.

Dozer safety is to be ensured at 3 levels, viz. equipment safety, operator safety and safe operating practices.

11.1 Equipment Safety

Dozers to be equipped with Roll over Protective Structure (ROPS) and/or Falling Object Protective Structure (FOPS), Crankcase and Radiator protective guards.

Safety features and protective measures incorporated in the machine to be in accordance with those listed in ISO 20474-1:2008 and ISO 20474-2:2008.

11.2 Operator Safety

i) Crew Members working within the dozer work area to wear Personal Protective Equipment (PPE) (for example orange vests, safety helmets/ hard hats, steel-toed safety shoes, and long pants).

ii) Eye protection to be worn wherever there is a danger of falling or flying debris from equipment or loads, particularly in windy conditions.

iii) Hand protection to be worn when handling cable or any other material where there is danger of cuts or puncture injury.

iv) Hearing protection to be worn when exposed to noise levels exceeding 85dBA.

v) Operator to always use seat belt while operating the machine.

vi) Operator to mount and dismount the dozer using only the steps and handholds provided on the dozer.

11.3 Safe Operating Practices

11.3.1 *Pre-Operation Activities*

i) Carrying out pre-shift inspection of the dozer, that includes fluid levels, brakes, steering, lights and signals, tires, hydraulic cylinders/lines, horns, operating controls, seat belts and safety devices.

ii) Operator must have a thorough understanding of the information provided in the operation manual supplied by the OEM with particular attention given to details of safety procedures.

iii) Qualified and properly trained operators only to be allowed for dozer operation.

11.3.2 *Operating Precautions*

Refer to **Appendix-IX**.

Appendix – I

DOZER APPLICAtIONS

1. LAND CLEARING

Clearing of the land involves several operations depending upon the condition of soil and topography, the amount of clearing required, type of vegetation and the purpose for which clearing is done. The operations may include, removal of soil to remove unevenness of the ground, removal of trees and stumps including roots, removal of vegetation etc.

2. StRIPPING

It is the removal of top soil that is not usable. Stripping is planned in such a way that haulage distance is minimum. For distances up to 100 meters, dozer is preferred, but for greater distances, scrapers should be deployed.

3. SIDE HILL CUttING

Side hill cuts should always be started from the top and then worked downward.

4. BACKFILLING

Here, material is pushed ahead of the dozer over embankments into ditches or against a structure. Angle dozers are found more suitable for this job as they can drift material into the trench while maintaining forward motion, **Fig. 27.**

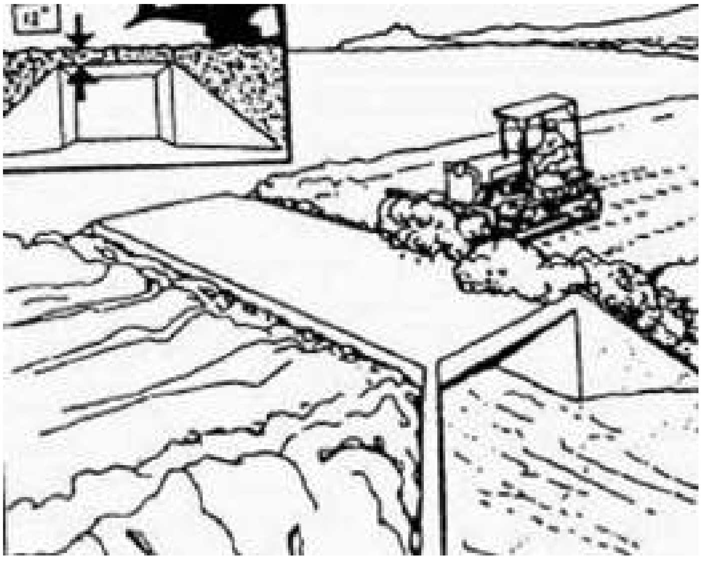

Fig. 27: Culvert Backfilling by Dozer

5. DItCHING

Rough ditches can be prepared by using dozer. These are constructed with a straight blade by working at right angles to the length of the ditch.

Small shallow ditches are usually cut with a motor grader. Large deep ditches are either cut with excavators or, if the cut is made before water enters the ditch, scrapers can be used. A dozer will follow the scraper and perform the final dressing of the slopes.

6. SPREADING

Dozer can be used for spreading the material hauled by trucks, scrapers etc. Depth of spread is adjusted considering the thickness required, **Fig. 28.**

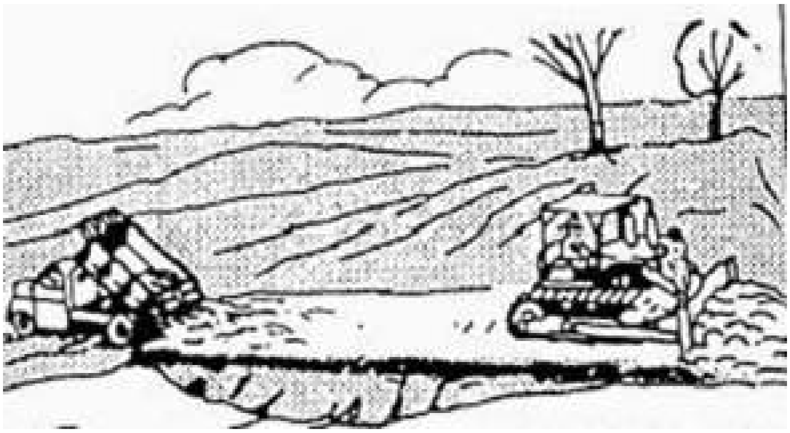

Fig. 28: Spreading by Dozer

7. DOZING ROCKS AND FROZEN GROUND

Rocks are generally removed by using one corner of the blade. Full power is thus applied on this section of the blade. Large sections of rocks are removed by using the blade to lift the rock, simultaneously applying power to the tracks.

In a similar fashion, dozer can be used to move frozen ground.

8. MAINtENANCE OF HAUL ROADS

9. CLEARING tHE FLOORS OF BORROW AND QUARRY PItS

10. DIGGING

A dozer while moving forward with the blade inserted in the soil digs it. If the blade is lowered further, more work can be done, thereby increasing the resistance as a thick slice requires more digging power than a thin one. The blade, during operation, should be lowered or raised gradually to avoid bumps in the path.

11. BREAKING PILE

A pile may be knocked down by walking into it with the blade at the desired grade, after which it may be spread or piled elsewhere. If the heap is too large, it may be cut away in parts, either directly, or if it is not possible, the side cut should be repeated from different angles.

12. SLOt DOZING

Slot dozing is the technique whereby the blade end spillage from the first pass or the sidewalls from previous cuts are used to hold material in front of the dozer blade on subsequent passes **Fig. 29**. When employing this method to increase production, cuts are to be aligned parallel, leaving a narrow uncut section between slots. Then, the uncut sections are to be removed by normal dozing. This technique prevents spillage at each end of the blade and usually increases production by about 20%. The production increase is dependent on the slope of the push and the type of material being pushed.

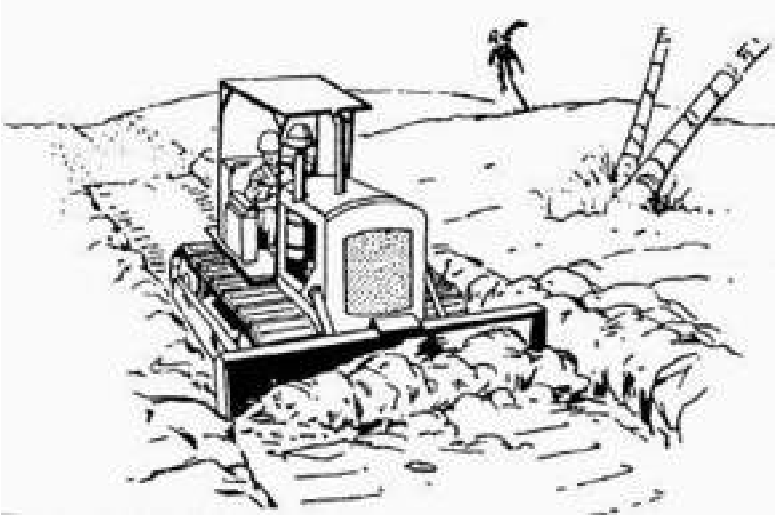

Fig. 29: Slot Dozing

13. BLADE-t O-BLADE DOZING

Another technique used to increase dozer production is blade-to-blade dozing (also referred to as side-by-side dozing) **Fig. 30**.

As the names imply, two machines maneuver so that their blades are right next to each other during the pushing phase of the production cycle. This reduces the side spillage of each machine by 50%. The extra time necessary to position the machines together increases that phase of the cycle. Therefore, the technique is not effective on pushes of less than 15m because of the excess maneuver time required. When machines operate simultaneously, delay to one machine is in effect a double delay. The combination of less spillage but increased maneuver time tends to make the total increase in production for this technique somewhere between 15 and 25%.

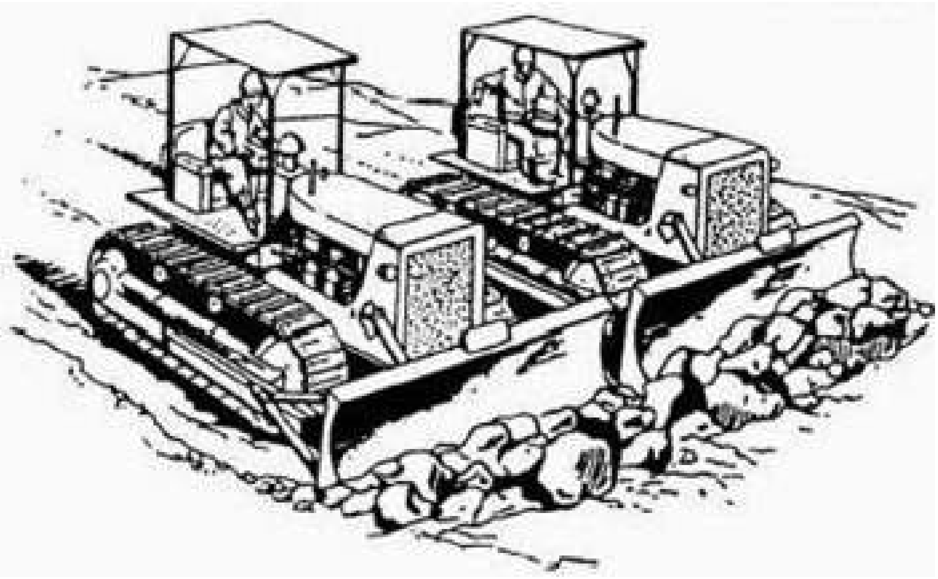

Fig. 30: Blade-to-blade Dozing

Appendix – II

DOZER SELECtION

t able 11 provides recommendations for selection of dozer depending on the size of road project for its deployment. Selection of the dozer will be governed by the dozer output requirement, keeping in view various factors like quantum of work and time horizon for the project at hand, site conditions, experience etc.

t able 11: Recommendations for Dozer Selection based on Size of Road Project

Sl. No.	Size of Road Project	Engine Power (Gross KW or HP)	Drawbar Pull (KN, in 2^{nd} Gear)
1	Small	KW>52 (HP> 70)	> 45
2	Medium	KW>75 (HP> 100)	> 90
3	Large	KW>104 (HP> 140)	>140

t able 12 provides typical dozer operating weight and blade type for road projects of different sizes.

t able 12: t ypical Dozer Operating Weight and Blade t ype for Road Projects of Different Sizes

Sl. No.	Size of Road Project	Operating Weight (Kg)	t ype of Blade
1	Small	> 7,500	Angle Blade
2	Medium	>15,000	Semi-U
3	Large	> 20,000	Semi-U or PAT

Appendix – III

DOZER OPERAtING SPACE

The minimum space required for turnaround of a dozer governs its maneuverability at work site and depends upon the steering mechanism/ technology.

A conventional crawler dozer does a pivot steering, through the conventional clutch and brake steering mechanism, with the inner track as axis and, therefore, requires space around for the machine to turn.

A crawler dozer with differential steering mechanism is capable of spinning about a vertical axis passing through its center of gravity (through counter rotation of tracks) and make a 180º turn. Thus, there is no need to move the machine forward or reverse.

Appendix – IV

DOZER INStRUMENt AtION

Advantages of Dozer Instrumentation:

i) Real time performance monitoring
ii) Improved reliability
iii) Reduced site costs
iv) Improved sustainability, accuracy, consistency and productivity
v) Ease of operation on account of better control
vi) Reduced risk and safer work environment
vii) Documentation of Job

t able 13 lists some important machine parameters, monitoring of which by using instrumentation techniques can enhance machine performance beyond that obtainable from conventional dozers.

t able 13: Important Machine Parameters to be monitored through Instrumentation

Sl. No.	Machine Parameter
1	Blade Lift
2	Blade Tilt
3	Blade Pitch
4	Depth of Ripper Shank
5	Track Slip
6	Material Movement (Track mapping)
7	Operating Conditions (Profiling terrain of work site and machine position relative to the site plan)

Intelligent dozing involves the use of automation for real time tracking of various parameters and analysis of the collected data by a control feedback system to optimize the machine performance for the intended application by matching blade loads with ground conditions-resulting in full blade loads and smooth grades with lesser effort.

1. Blade moves to target surface until load reaches a preset level.
2. The blade automatically raises to minimize track slip.
3. Should the load decrease, blade will lower to re-load blade to an optimum level.

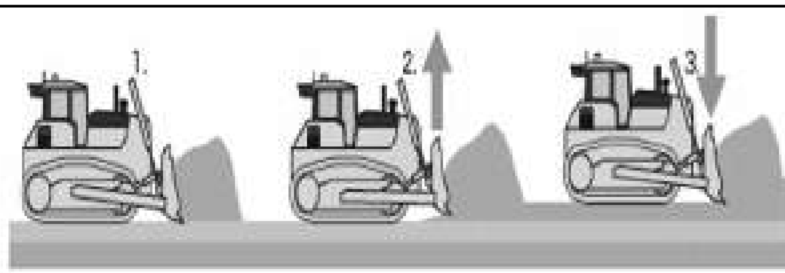

Fig. 31: Intelligent Dozing - Automatic Blade Control

Fig. 31 illustrates how intelligent dozing helps optimize dozer performance as per target design data for applications ranging from heavy (rough) dozing to finish grading. Loading of the blade at the start of the cut is controlled as per set parameters. During the pass, if the load on the blade increases during heavy dozing operation, the blade is automatically raised to control the load and minimize shoe (track) slip to ensure efficient dozing. When the blade approaches the target design surface, the blade will follow it for accurate finish grading.

Appendix – V

INFORMAtION t O BE FURNISHED BY tHE MANUFACtURER t O tHE PURCHASER

1. Model and Type of Dozer
2. Brief description of the Dozer and its features
3. Specific features, if any
4. Product Pricing for each configuration /Finance tie up arrangement
5. Safety Manual
6. Operation Manual
7. Parts Catalogue
8. Repair / Service Manual
9. Operation & Maintenance Manual
10. Training Schedule / Provision for Operation & Maintenance Staff
11. Address of the Dealers / Offices where spare parts would be available
12. Address of workshops for major repair

Appendix – VI

EMISSION NORMS

While mechanization in the highway sector has contributed immensely in reducing project costs and ensuring quality and speedy disposition of work, consumption of fossil fuels to run the various machinery, plants and equipment is increased many folds, thereby leading to environmental hazards and pollution. It is therefore necessary to strike a balance between the two such that the carbon footprint in the highway sector due to mechanization does not exceed the emission norms.

As per the Government of India, Ministry of Road Transport and Highways, Notification No. GSR 276(E), dated 10.11.2007, the limit values of emission norms applicable for both type approval (TA) and conformity of production (COP) testing in respect of construction equipment, are given in **t able 14**.

Table 14: Emission Norms for Construction Equipment Vehicles as notified by MoRT&H

Bharat Stage III	Applicable with effect from	CO	HC + NO_x	PM
Category		g/kWh		
kW < 8	1-Apr-2011	8.00	7.50	0.80
8 ≤ kW < 19	1-Apr-2011	6.60	7.50	0.80
19 ≤ kW < 37	1-Apr-2011	5.50	7.50	0.60
37 ≤ kW < 75	1-Apr-2011	5.00	4.70	0.40
75 ≤ kW < 130	1-Apr-2011	5.00	4.00	0.30
130 ≤ kW ≤ 5600	1-Apr-2011	3.50	4.00	0.20

Appendix – VII

EStIMA tION OF DOZER PRODUCtIVItY - PRACtICAL APPROACH

A practical approach to estimate dozer productivity is to refer to the chart that the OEM generally provides for the various models of machines manufactured by it under the dozer family (taking into consideration ideal conditions of dozer operation) and, thereafter, work out the dozer output of the individual machines for the expected average haul distance as per site conditions.

Fig. 32 illustrates the typical productivity (under ideal test conditions) in terms of loose volume versus average haul distance for various engine power capacities of dozers with semi-U blades available in the market.

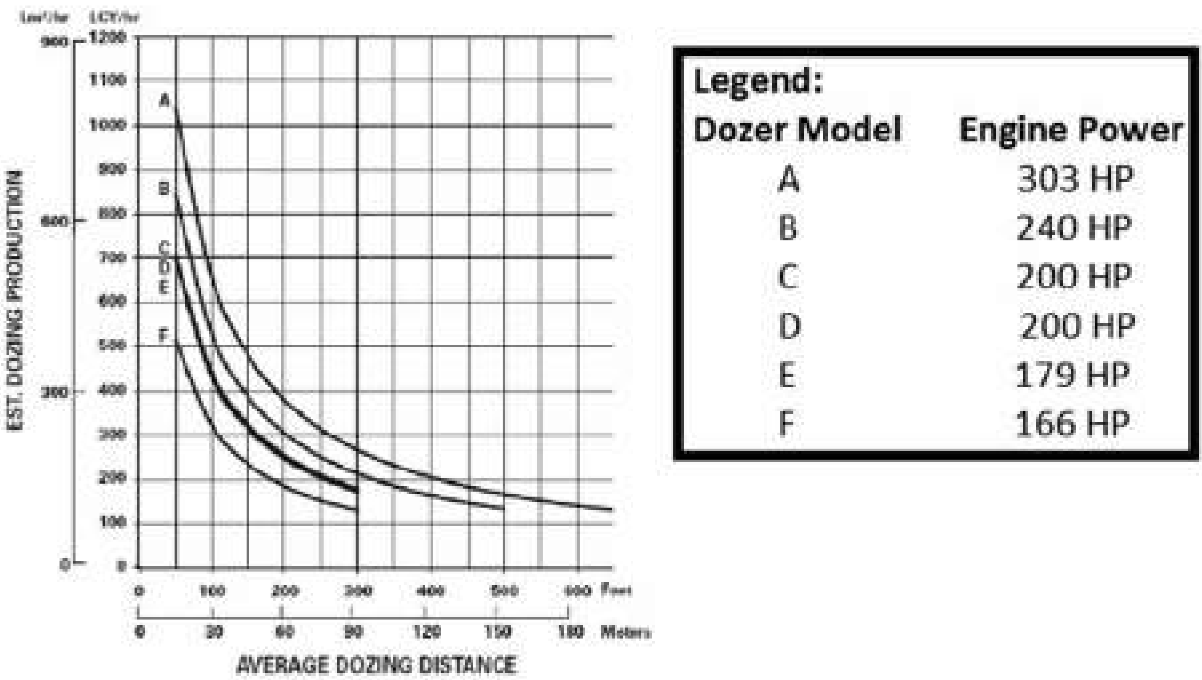

Fig. 32: t ypical Estimated Dozing Production versus Average Dozing Distance for a Dozer

Actual dozer productivity depends more on the condition of material (loose or packed) and how difficult it is to be cut and drifted than on the type of material. Taking suitable correction factor into account, it will generally be seen that the actual dozer productivity will be between 30% to 70% of that indicated by the chart **(Fig. 32)** for the corresponding haul distance.

For dozers with semi-U blade, engine power of greater than 160 HP and having average haul distance of 50 m, the productivity under ideal test conditions is usually not less than 380 cum/hour (loose volume) and, assuming a correction factor of 0.6 (refer to **Appendix-VIII)**, works out to not less than 230 cum/hour (loose volume).

Appendix – VIII

SAMPLE CALCULAtION FOR EStIMA tION OF DOZER OUtPUt/ ACtIVItY DURA tION

Suppose, 80000 cum(bank volume) of site [material density= 1800 kg/cum (loose)] is to be cleared using two dozers having semi-U blades and engine power 160 HP. Expected average haul distance is 50 m.

Step 1:	For 160 HP dozer with semi-U blade and average haul distance 50 m, dozer maximum production (loose volume) under test conditions (from OEM's chart)	= 380 cum/hour
Step 2:	Correction Factors (to be provided by OEM):	
	Operator Efficiency (assuming "excellent")	= 1.0
	Material Type Correction Factor (assuming "hard to drift")	= 0.8
	Operating Technique Correction Factor (assuming "slot dozing")	= 1.2
	Visibility Correction factor (assuming "clear")	= 1.0
	Job Efficiency (assuming "50 working minutes per hour")	= 0.83
	Grade Correction Factor (assuming "flat ground")	= 1.0
	Material Density Correction Factor [assuming OEM's dozer production chart prepared for test material with density 1370 kg/ cum(loose)] = 1370÷1800	= 0.76
	Total Correction Factor = 1.0 x 0.8 x 1.2 x 1.0 x 0.83 x 1.0 x 0.76	= 0.61
Step 3:	Actual Estimated Dozer Production (loose volume) = 380 x 0.61	= 230 cum/hour
	Actual Estimated Dozer Production (bank volume) = 230 x 0.75 (assuming load factor 0.75 for 50% rock, 50% earth condition of site)	= 172.5 cum/hour
Step 4:	Number of Dozers	= 2
Step 5:	Assume, Number of working hours per day	= 7.5
Step 6:	Actual Estimated Production (bank volume) per day = 172.5 x 2 x 7.5	= 2587.5 cum/hour
Step 7:	Number of Days required for 80,000 cum of site clearance work = 80000/2587.5	= 31 days
Step 8:	Assuming 25 working days in a month, time period required to complete the work = 31÷25	= 1.24 months

Appendix – IX

DOZER OPERAtION- DO'S AND DONt'S

I) Prior to dozer operation, work area to be checked for obstructions and hazards including ditches, slopes, hills, excavations, streams, and underground and above ground utility lines, overhead power lines etc.

ii) Proper traffic control to be ensured when operating dozer on a public thoroughfare or in an area close to vehicle traffic or obstructing it. Flaggers to be assigned wherever signs and barricades cannot control traffic.

iii) Never carry passengers on a dozer and stunt driving is prohibited.

iv) Do not operate a dozer with a leaking fuel system or leaking brake system.

v) Dozer to be operated only at speeds that allow maintaining control of the machine at all times.

vi) Dozer blades and attachments to be kept close to the ground while moving the machine.

vii) Dozer to be operated only from the sitting position, never from a standing position.

viii) Dozer to be parked on level ground whenever possible.

ix) Dozer to be equipped with an automatic back-up alarm that can be heard throughout the worksite.

x) Engine to be shut down during refueling of machine.

xi) Never use a dozer to demolish structures that are taller than the machine itself, unless there is adequate overhead protection.

xii) Proper procedures to be followed for dozer lockout, block out and tag out so that the machine is immobilized and secured against inadvertent movement at the time of machine service/repair/inspection.

xiii) Operator to use proper towing procedures and equipment for dozer attachments.

xiv) Extreme caution to be exercised, when operating dozer near the edge of a cut, to avoid overturning of machine.

xv) Steep incline should be climbed slowly.

xvi) Do not attempt a turn on a steep slope. Sliding sideways may turn dangerous if the low side of the dozer hits a solid rock or a stump.

xvii) Coupling of trailing equipment to a dozer should be done with extreme caution. Equipment should be coupled with the dozer stopped and the clutch, if so equipped, disengaged. Additionally, set the brake and lower the blade.

xviii) When towing a heavy load downgrade, the dozer should be kept in low gear.

xix) Before dismounting a dozer and at the end of a workday, operator should secure the dozer blade by lowering it to the ground. Lowering the blade prevents the dozer from rolling and also eliminates the possibility of the blade falling on someone.

xx) Whenever it is necessary to work on the dozer with the blade up, especially when changing cutting edges, the blade must be securely blocked to prevent it from falling accidentally.

xxi) A dozer should never be used for clearing trees without being equipped with an operator's protective cage (brush cage)

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(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the code/guidelines/manual, etc. from the date specified therein)