

## **CHAPTER 7**

### **ENGINEER HEAVY EQUIPMENT**

#### **SECTION 1**

#### **GENERAL**

#### **INTRODUCTION**

1. Most engineer units are equipped with various types of heavy equipment. Engineers are required to plan and supervise the employment of heavy equipment, and shall know the types available, characteristics and capabilities. The aim of this chapter is to provide a brief description of the equipment available and how they are used.

2. Engineer heavy equipment must be differentiated from engineer equipment (see Chapter 9). Engineer heavy equipment consists of equipment, vehicles and their attachments, which are primarily used for horizontal and vertical construction and maintenance tasks. Some examples of heavy equipment are: dozers, graders, scrapers, loaders, cranes, snow clearing equipment, and excavators.

#### **GENERAL SAFETY PRECAUTIONS**

3. Engineer heavy equipment operations are characterized by large, heavy, unwieldy vehicles, with restricted fields of vision, maneuvering often in the presence of personnel working on foot, and often at night. It is a very dangerous environment. The following safety precautions will help prevent accidents. Additional precautions may be necessary depending on the conditions at the task site and the particular machine being used.

4. Operators shall:

- a. be familiar with the operator's manual and operate the machine within its capabilities and limits;
- b. be familiar with the work site - above ground (eg. weather conditions and obstructions), at ground level (eg. presence of obstacles) and below ground (eg. underground utilities);

- c. conduct a walk around inspection of the machine to check for:
  - (1) coolant, fuel and hydraulic line leaks,
  - (2) debris left in the engine compartment,
  - (3) the condition of attachments (cutting edges and teeth),
  - (4) damaged components both inside and outside of the operator's cab,
  - (5) clear visibility (windows, mirrors and running lights), and
  - (6) personnel in the machine's immediate area.
- d. use seatbelts;
- e. obey hand signals and ground guide;
- f. check for warning tags (servicing and non-serviceable) on the steering wheel or starter switch indicating that the machine should not be used or even moved;
- g. test all controls for proper operation prior to moving the machine;
- h. ensure that unattended equipment is shut off and all attachments lowered to the ground;
- j. park equipment (utilizing the parking brake) on level ground when possible, otherwise at right angles to any slope with wheels blocked;
- k. never allow riders on the outside of the machine or personnel to stand in the pivot area of an articulated machine while the engine is running;
- m. shut off the machine during refueling;

- n. never move a load over personnel or vehicles;
- p. carry the attachments low for good stability and visibility while travelling;
- q. allow clearance for overhead dangers, such as overhanging trees and banks and overhead wire, especially high voltage lines;
- r. keep the equipment back from the edges of banks and excavations, or if it cannot be avoided, face the machine towards the bank's edge while operating;
- s. on haul roads, give loaded vehicles the right-of-way; and
- t. when loading and unloading a machine for transport:
  - (1) load and unload only on level ground;
  - (2) block the transport vehicle's wheels;
  - (3) use ramps with sufficient strength, height and angle;
  - (4) ensure the trailer bed is free of all slippery substances, such as clay, oil, or snow;
  - (5) know the manufacturer's recommended procedure for loading and unloading the machine;
  - (6) only load and unload a machine with the assistance of a ground guide, and
  - (7) ensure the machine is properly secured before moving the trailer.

5. **Danger:** If your machine comes in contact with a charged line, stay in the cab. Do not allow anyone close to the machine until the power has been cut off or until contact with the line has been broken.

## SELECTION OF HEAVY EQUIPMENT

6. Most earthmoving equipment can handle a wide variety of tasks in different conditions, but there will always be a best method and an optimum type of machine for each task. The choice of the right method and type of equipment for a task is a complicated problem involving many factors, including:

- a. site conditions;
- b. tactical situation;
- c. availability of the equipment and attachments;
- d. time available;
- e. operator training and supervision; and

7. The following sections of this chapter describe the general capabilities and uses for each type of equipment. Annex A lists various heavy equipment tasks and the suitable heavy equipment. A "rule-of-thumb" guide for the most efficient choice of earthmoving equipment is shown on the next page:

Distance	Heavy Equipment
30 m	Optimum dozer haul distance
0-100 m	Dozers, tracked or wheeled
0-300 m	Loaders in the "load and carry" role
100-450 m	Towed scrapers
300-1500 m	Self-propelled scrapers
Over 1500 m	Haul vehicles with excavators or loaders

Fig 7-1-1 Earthmoving Rule of Thumb

8. **Tracks Versus Wheels.** In addition to selecting the correct type of heavy equipment for a task, it is sometimes necessary to choose between a tracked or wheeled machine.

- a. Tracked tractors have the advantage of greater traction efficiency and thus greater digging/pushing capacity. They are, however, slower and require road

transportation. They can cause considerable damage to the ground surface particularly when turning. Tracked tractors require more maintenance and cause considerable operator fatigue because of the vibration. These factors greatly affect the output of the machine.

- b. Wheeled tractors have slightly less digging capability however they have a faster cycle time. They can move quickly without requiring transportation, and are therefore suited to provide mobility support for combat forces. Wheeled tractors cause less operator fatigue and in general, require less maintenance. The exception being:
  - (1) in hot climates where the tires are exposed to bright sunshine, and
  - (2) on rocky surfaces or in timbered areas where the tires may be punctured.

## **HEAVY EQUIPMENT OUTPUT**

- 9. Heavy equipment output is a function of a variety of factors, including:
  - a. selected heavy equipment and attachments;
  - b. task and site conditions;
  - c. method of employment and haul distances; and
  - d. operator efficiency and supervision.
- 10. Heavy equipment output formulae and factors are included and explained in manuals B-CE-320-002/PF-001 and B-GL-320-006/FP-001.

## SECTION 2

### EARTHMOVING EQUIPMENT

#### GENERAL

1. Earthmoving equipment is used for digging or picking up earth or other materials, moving or carrying it elsewhere, and stockpiling or spreading it. The earthmoving machines discussed in this section are dozers, excavators, loaders, backhoes (industrial tractors), graders, scrapers and dump trucks.

#### TRACKED DOZERS

2. A dozer is a tractor with a blade mounted. Dozer blades are of three general types, straight bulldozer (right angle to the tractor), angle (angled relative to the forward motion of the tractor) and universal (“U”). Tracked dozers are used for digging, pushing and spreading material for short excavation (up to 100 m), and as auxiliary machines to other construction equipment. A prime mover is used to move tracked dozers between work sites.

3. The main characteristics that categorize tracked dozers are horse power available, track width, weight and performance (output capability). Dozers may be equipped with an armoured cab. Dozers in the Canadian Forces are divided into three categories as follows:

- a. Heavy - D8, D9;
- b. Medium - D6, D6D, D7, TD15, TD20, Case 1450; and
- c. Light - D4, D5.

4. **Dozer Attachments.** Dozers are normally equipped with the following attachments:

- a. a straight bulldozer blade (Fig 7-2-1), angle blade (Fig 7-2-2) or universal blade (Fig 7-2-3),

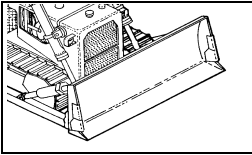


Fig 7-2-1 Straight Blade

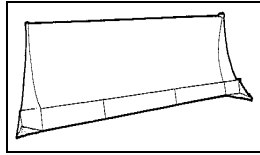


Fig 7-2-2 Angle Blade

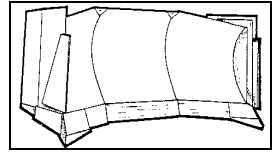


Fig 7-2-3 Universal Blade

- b. a tilt mechanism, and
- c. a ripper or winch.

5. For specific jobs, dozers may be equipped with the following attachments:

- a. a brush rake,
- b. a stump splitter,
- c. pusher blocks,
- d. a side crane (for pipelines),
- e. a backhoe, and
- f. a power control unit (PCU) for scrapers.

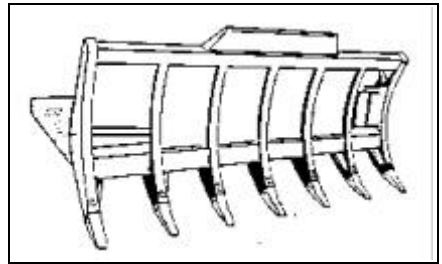


Fig 7-2-4 Bush Blade

6. **Heavy and Medium Dozers.** Heavy and medium dozers are suitable for the following tasks:

- a. removing stumps and roots, tree felling and clearing, and rock removal (heavy dozers are used for large rocks and trees);
- b. digging road, airfield and excavating (cut and fill) ;
- c. towing scrapers and compactors;

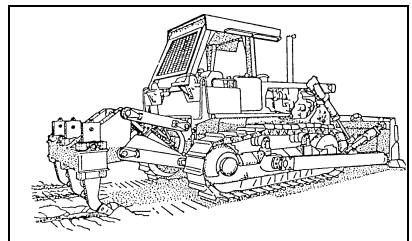


Fig 7-2-5 Heavy Dozer with Ripper

- d. spreading and stock-piling material;
- e. filling excavations;
- f. moving obstacles, rubble, debris and heavy snow; and
- g. breaking up (ripping) roads.

7. **Medium Dozers.** In addition, medium dozers are suitable for the following tasks:

- a. digging vehicle and weapon emplacements; and
- b. digging antitank ditches.

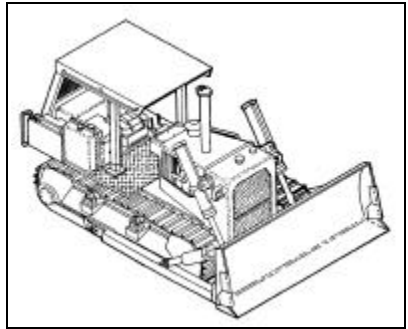


Fig 7-2-6 Medium Dozer

8. **Light Dozers.** Light dozers are suitable for:  
rollers.

- a. filling craters and excavations;
- b. spreading material;
- c. clearing light scrub, rubble and light snow; and

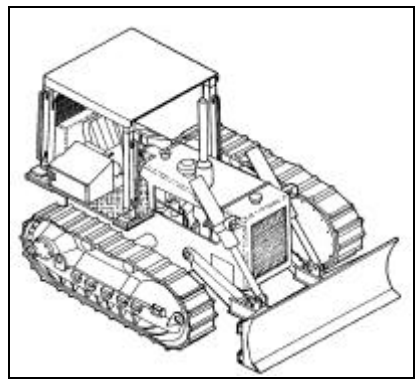


Fig 7-2-7 Light Dozer

- d. towing a rotary plow, or compactors or snow

### WHEELED DOZERS

9. The wheeled dozer is a wheeled tractor with a blade mounted. The primary use of wheeled dozers is rapid, short haul excavation (digging, pushing and spreading earth and snow) at distances of up to 100 m.

10. Wheeled dozers are categorized as light, medium and heavy by horsepower available, tire size, weight and performance as measured by output capability. Their high speed road mobility and high work output are ideal for supporting combat forces in the advance on the battlefield.

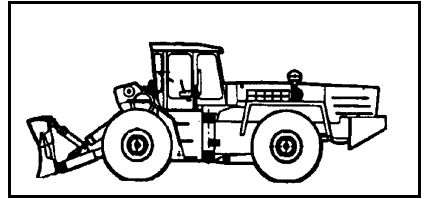


Fig 7-2-8 Zettlemeyer Wheeled Dozer

### EXCAVATORS

11. An excavator digs and discharges material with a single bucket suspended from or mounted on a boom. It can be self-propelled, mounted on crawler tracks, or wheels, which allows it to move between sites.

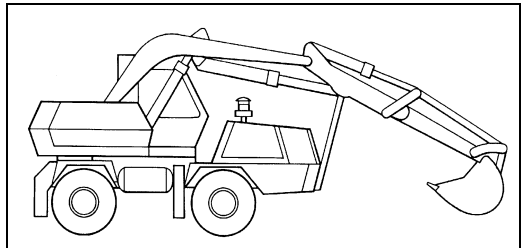


Fig 7-2-9 Typical Wheeled Excavator

12. The excavator may be equipped with the following attachments:
- a. a wrist-o-twist (permits the bucket to be twisted 40 degrees to either side of centre);
  - b. a general purpose, ditch forming, light duty or severe duty (frost) bucket;
  - c. a face shovel;

- d. a pavement breaker;
  - e. a vibratory compactor;
  - f. a hydraulic impact hammer;
  - g. an air/hydraulic drill;
  - h. a grapple; and
  - j. a thumb.
13. The excavator is suited for the following jobs:
- a. digging antitank ditches, field fortifications and vehicle pits;
  - b. excavating building construction sites and sanitation facilities;
  - c. excavating and improving water crossing sites;
  - d. loading haulage vehicles;
  - e. light lifting tasks; and
  - f. road and airfield construction and repair, including:
    - (1) breaking pavement,
    - (2) excavating craters and culverts,
    - (3) ditching, and
    - (4) compacting soil.

## LOADERS

14. Loaders or Front End Loaders (FELs) are self-propelled tractors equipped with a front scoop bucket. The FEL loads material into the scoop through the machine's forward motion, it then lifts, transports and discharges the material into a stockpile or onto a vehicle (eg. a dump truck). Loaders can be either wheeled or tracked and vary in size and capacity

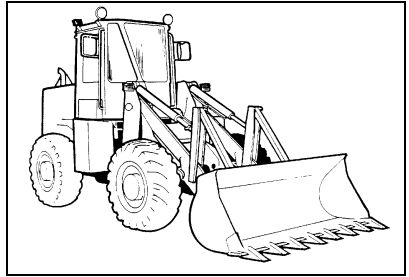


Fig 7-2-10 Typical Loader

15. Attachments. Loaders are normally fitted with a multi-purpose (4 in 1) bucket and may be equipped with the following attachments:

- a. a backhoe bucket;
- b. a forklift to replace the detachable bucket;
- c. a pavement breaker;
- d. a sweeper, snow bucket or snow blower; and

16. **Wheeled Loaders.** A wheeled loader is capable of rapidly loading material. It has a significant radius of operation before it must be transported on a prime mover. Wheeled loaders are suitable for the following tasks:

- a. excavating defensive positions, support weapon emplacements, command posts and field sanitation facilities;
- b. loading haulage vehicles;

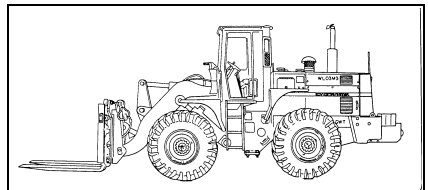


Fig 7-2-11 Wheeled Loader with Forklift Attachment

- c. lifting using forklift and crane attachments;
- d. loading hoppers during crusher operations;
- e. excavating and back-filling;
- f. and cleaning and removing rubble, debris and heavy snow.

17. **Tracked Loaders.** A tracked loader is capable of loading material in areas which are not accessible to wheeled loaders and quarry operations, however a prime mover is required to move from site to site. Tracked loaders are suitable for the following tasks:

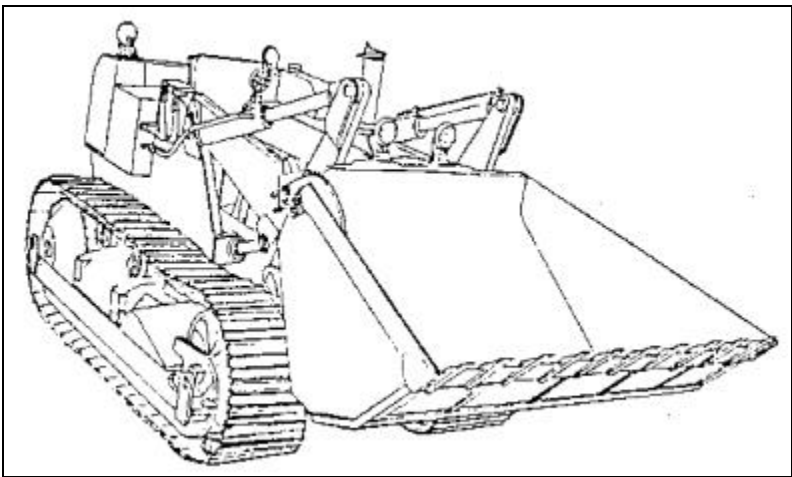


Fig 7-2-12 Tracked Loader

- a. loading haulage vehicles;
- b. backfilling and excavating;
- c. clearing rubble, debris and snow; and
- d. loading hoppers for crusher operation.

## INDUSTRIAL TRACTOR

18. The industrial tractor is an agricultural type tractor normally fitted with a scoop bucket in front and a small backhoe bucket at the rear.

19. The backhoe bucket may be replaced with a variety of hydraulically operated attachments, including a back spreading blade, a hydraulic earth auger, a vibrapacker, or pavement breaker. The front scoop bucket may be replaced with a 4 in 1 bucket, a snow bucket or a sweeper. A small portable backlift and ripper teeth can be attached to the bucket.

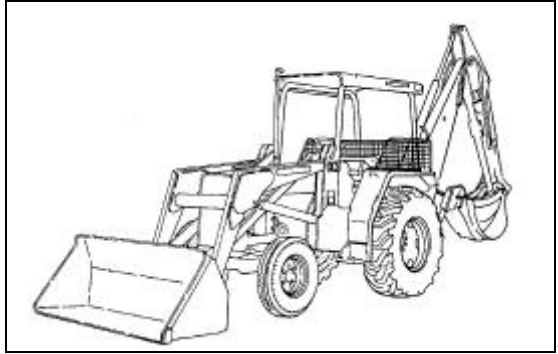


Fig 7-2-13 Typical Industrial Tractor

The industrial tractor is normally used for:

- a. excavating individual and support weapon battle trenches and small command posts;
- b. small excavating and backfilling, including field sanitation facilities;
- c. light landscaping, levelling and ditch maintenance;
- d. clearing debris and light snow;
- e. drilling holes up to 1.5 m deep; and
- f. loading, unloading and carrying of small stores.

## GRADERS

21. A grader is a self-propelled machine with an adjustable blade positioned

Between the front and rear axles to cut, move and spread materials, usually to grade. Graders may have a rigid or articulating frame. The articulating frame decreases the turning radius and increases production.

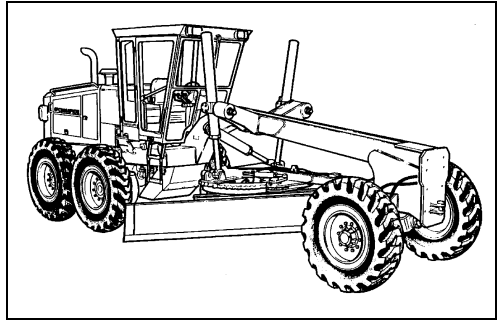


Fig 7-2-14 Typical Grader

22. Graders may be equipped with the following attachments:
- a. a V-plow for snow removal
  - b. a wing plow to cut down high snow banks;
  - c. a scarifier to loosen hard soils;
  - d. a rear mounted ripper; and
  - e. a front mounted dozer blade.
23. Graders are suitable for the following horizontal construction tasks:
- a. cutting and maintaining ditches;
  - b. scarifying, levelling and shaping surfaces;
  - c. stripping of light soil;
  - d. clearing snow; and
  - e. spreading fill in layers of uniform thickness.

## SCRAPERS

24. Scrapers are large earthmoving machines capable of digging, loading, hauling, dumping and spreading material. They can be either towed or self-propelled. They are particularly useful on large earthmoving tasks such as airfield or road construction which involves numerous cuts and fills. Scrapers make shallow cuts while loading, transport large loads for considerable distances at relatively high speeds, and spread materials in a thin uniform layer. They operate most effectively over hauling distances 100-450 m for towed scrapers and 300-1500 m for self-propelled scrapers. Motorized and towed scrapers usually require a dozer as a puller during the loading cycle. Self-propelled scrapers can work alone and self-load, but only at a greatly reduced output.

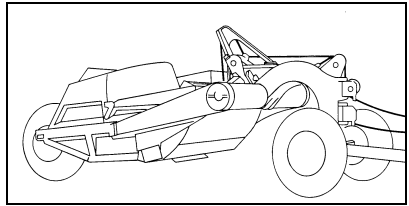


Fig 7-2-15 Typical Towed Scraper

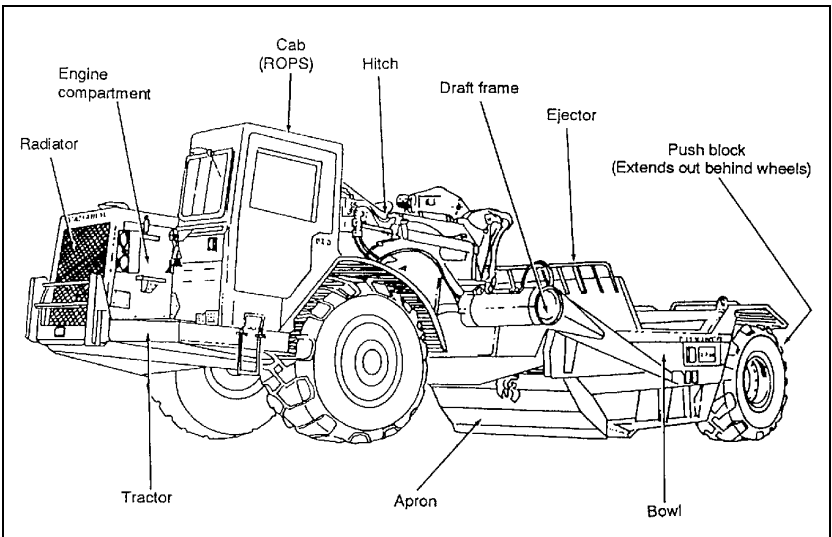


Fig 7-2-16 Typical Self-Propelled Scraper

25. Scrapers are not held by engineer units at this time, but can be made available through rental or other agreements.

## DUMP TRUCKS

26. There are a variety of dump trucks in service, both military and commercial pattern, ranging in size from 5-Ton to 20-Ton. They may be powered by diesel or gasoline engines with varying load capacities. Dump trucks normally dump their load at the rear of the vehicle, however some types tip the load over the side. They can also haul a variety of trailers.

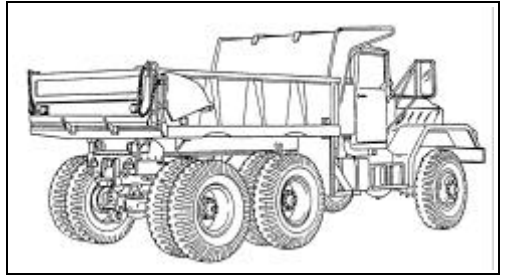


Fig 7-2-17 Typical Dump Truck

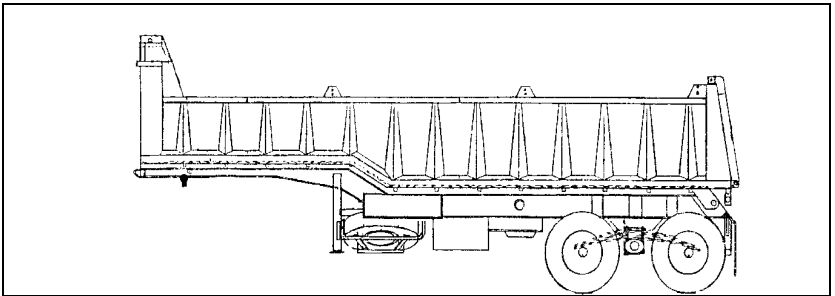


Fig 7-2-18 30 Ton Dump Trailer

27. Dump trucks are suited for the following jobs:
- a. hauling and spreading earth, rock, aggregate and construction material for airfield, road or other construction and maintenance tasks;
  - b. hauling mines for minefield laying, and towing a mechanical minelayer; and
  - c. hauling engineer and defence stores

## SECTION 3

### CONSTRUCTION EQUIPMENT

#### GENERAL

1. Construction equipment covers a very wide range of machines which may be needed on a task site to complete construction, such as:
  - a. rock crushers;
  - a. compaction equipment;
  - b. paving and mixing equipment; and
  - c. pile driving equipment.

#### ROCK CRUSHERS

2. Rock crushers are machines used to provide graded aggregate for horizontal construction projects. Rock crushers use crushing equipment (either pressure or impact) to reduce rock or stone to smaller sizes, called crusher-run material. Screens separate the crusher-run material into appropriate grades. Washing equipment is used to wash the crusher-run material to remove the left over fines. Conveyor belts and rock drills are also used. Rock crusher operations requires the employment of other types of heavy equipment, including loaders and dump trucks.

#### COMPACTION EQUIPMENT

3. Compaction equipment is used to increase the stability and durability of all hardstanding areas by increasing the density of the material. There are various types of equipment which can be used depending on the material, moisture content and job requirement.

4. **Rollers.** Rollers can be either self propelled or the towed type. Either type may be made available to be used by engineer units and are described below.

- a. **Sheepsfoot Roller.** Used mainly for compacting cohesive soils of low moisture content, it is normally towed by a tracked tractor

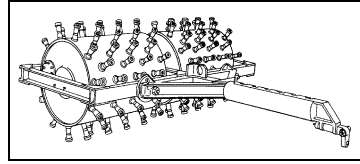
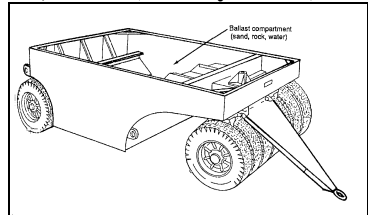


Fig 7-3-1 Sheepsfoot Roller

- b. **Pneumatic Tired Roller, Towed (Wobbly Wheel).** Is used for compacting fine grained soils, sub-bases, bases and surfaces. It is normally towed by a wheeled tractor.



Pneumatic Tired Roller, Towed

- c. **Vibrating Roller.** This roller can be used on non-cohesive soils. It can also be used on materials containing up to a 50 percent cohesive element providing water content is not excessive. It can be towed by either a wheeled or tracked tractor.

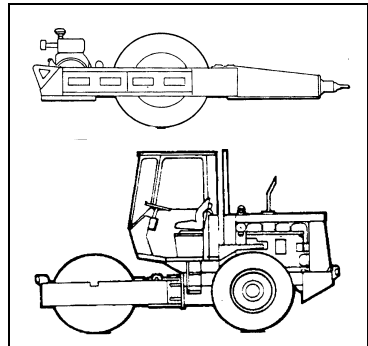


Fig 7-3-3 Vibrating Roller (Towed and Self Propelled)

5. **Snow Roller.** The snow roller is used in the construction of snow compacted airstrips. They are used in sets of three with removable steel plates to adjust weight. It is normally towed by a tracked tractor and is air droppable.

6. **Water Distributor.** Water distributors are vehicles or trailers capable of distributing water evenly over a surface. They are required during road and airfield construction to improve compaction by increasing moisture content. They are also used to control dust on earth roads.

## PILE DRIVING EQUIPMENT

7. The pile driver is used to drive bearing or sheet piles into the ground for the construction of buildings and supporting structures. It consists of a hammer and a support system for the hammer and pile. The Canadian Forces presently uses the Grove AT865 crane with a Delmag D8-22 5-tonne diesel-powered hammer which consists of a cylinder containing a moving piston or ram.

8. **Safety.** General safety procedures for heavy equipment operation, as well as those specific for the crane and pile driver must be adhered to.

9. **Operation.** The pile driver is operated by a three man crew (crane operator, hammer operator and detachment commander). It takes approximately four hours to set up the pile-driver from scratch or two hours if it is already prepared on a lowbed. The rate of pile driving depends on the soil and the site conditions. The normal rate of driving is five minutes for a 10 m pile, however the constant moving of the crane slows the process down. For more detail on pile driving procedures, refer to Chapter 14. Refer to the operator manual for specific pile driver operating procedures.

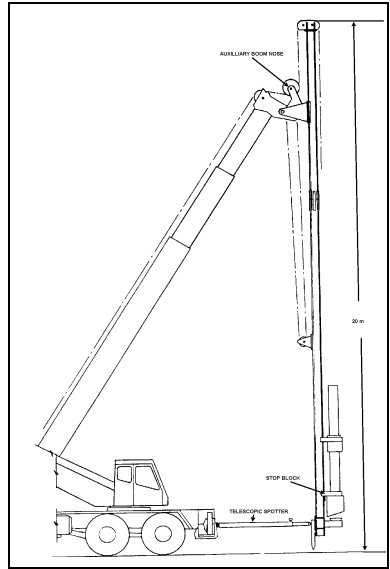


Fig 7-3-4 Crane with Pile Priver

## SECTION 4

### MATERIAL HANDLING EQUIPMENT

#### GENERAL

1. Material handling equipment includes equipment used to load, unload and carry materials such as mines, bridging loads, defence stores, pallets and containers, etc.

#### CRANES

2. There are various types of cranes available, including an airportable crane. However, the crane most commonly used in engineer units is the Krupp crane which has a hydraulic telescopic boom. There are boom extensions of 8 and 13 m. It is mounted on a wheeled chassis which enables it to move quickly between sites. It has a maximum lift capacity of 19.9 tonnes at a working radius of 4 m and 360 degree rotation.

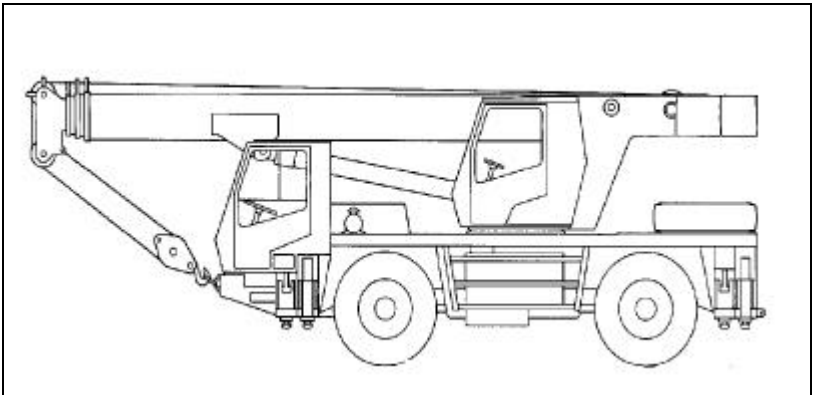


Fig 7-4-1 Krupp Crane

3. The other crane available is the Grove AT865 with greater lifting capability and a longer boom. The lift capacity is 41.1 tonnes at a working radius of 4.5 m with a 360 degree rotation.

20. Cranes are suitable for the following tasks:

- a. lifting loads such as containers, pallets, vehicles, construction material, boats, bridging and rafting loads;
- b. loading and unloading vehicles;
- c. lifting loads during construction tasks, such as steel girders; and
- d. pile driving.

5. All Field Engineers shall be familiar with hand signals used to guide the crane operator. Before the task, the crane operator will determine the best location for the crane, the maximum lift based on the load and the boom extension required, and brief the ground crew on the hand signals to be used.

## **FORKLIFTS**

6. Forklifts are self-propelled wheeled vehicles with moveable forks mounted on the front, which are used for handling palletized loads. Some forklifts are equipped with zoom boom forks.

21. The following types of forklifts may be available:

- a. **Warehouse Pattern Forklifts.** These vehicles have small wheels and are designed to work indoors in warehouses or outside on hard standing. The lift capabilities will vary with the size of the vehicle. These forklifts can be gasoline, propane or diesel powered.

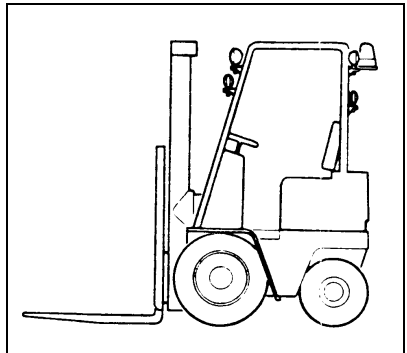


Fig 7-4-2 Warehouse Pattern Forklift

- b. **Rough Terrain Forklifts.** These vehicles are designed to work outside. They are well suited to handling palletized stores in engineer mine dumps. Maximum lift will depend on the vehicle load capacity;

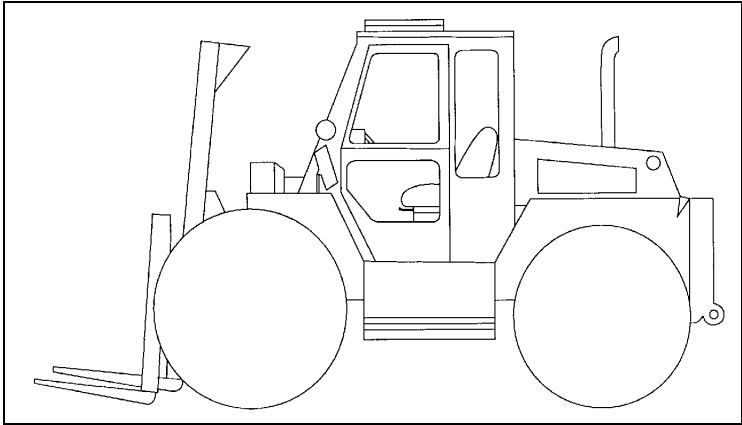


Fig 7-4-3 Rough Terrain Forklift

## SECTION 5

### TRANSPORT EQUIPMENT

#### GENERAL

1. Engineers also need vehicles capable of transporting heavy equipment (particularly tracked dozers/loaders) between work sites and on administrative road moves. Transport equipment includes:

- a. tractor trailer units; and
- b. tiltbed trailers.

#### TRUCK TRACTOR AND TRAILERS

2. **Tractor Trailer.** The current tractor trailer unit is the HLVW 20-Ton tractor with a 35-Ton variable deck trailer (front and rear gooseneck) (Fig 7-5-2). It is suited for transporting engineer stores and equipment on long and short hauls. It has some cross country capability and can be used as a recovery vehicle, if necessary.

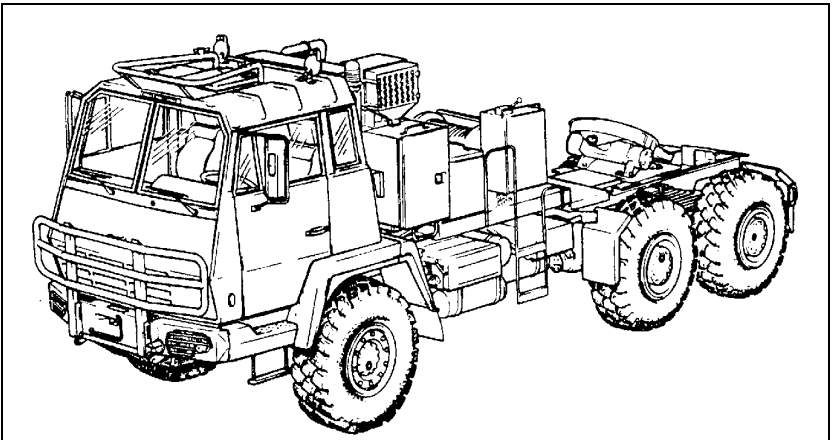


Fig 7-5-1 HLVW 20 Ton Tractor

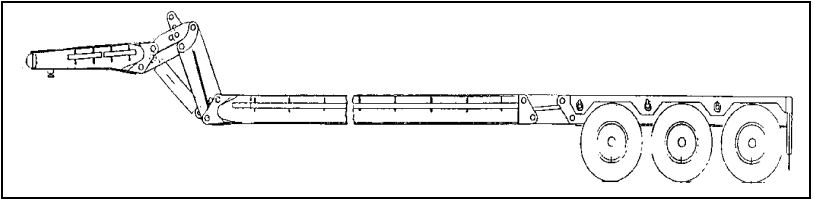


Fig 7-5-2 35 Ton Variable Deck Trailer

3. **Tiltbed Trailers.** Tiltbed Trailers (Beavertails) can carry loads up to 15 tons are designed for ease of loading so it can be pulled by a 5-Ton dump truck. The tiltbed trailer is suited for the following tasks:

- a. transporting APCs;
- b. hauling light engineer equipment and attachments under 15-tons;
- c. recovering unserviceable vehicles; and
- d. hauling bulk engineer stores and defence stores.

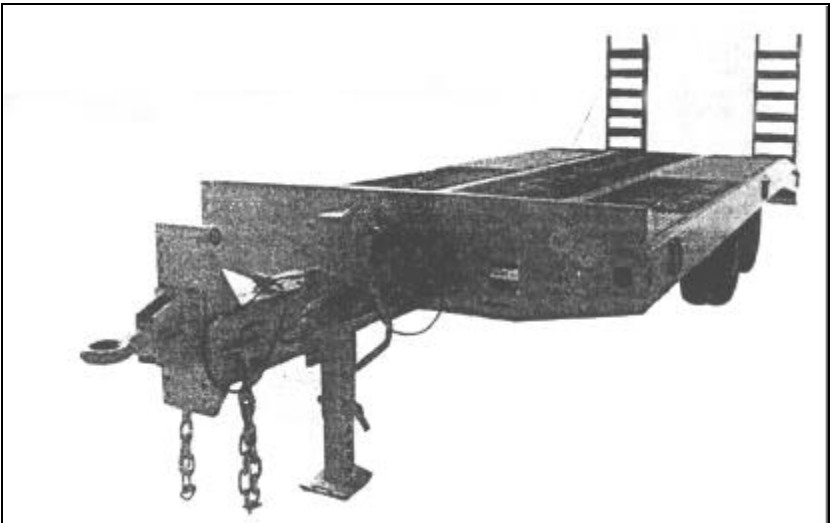


Fig 7-5-3 Tiltbed Trailer (Beavertail)

## ANNEX A

## HEAVY EQUIPMENT SELECTION

Ser	Operation	Heavy Equipment	Remarks
1	Clearing and grubbing- scrub and trees up to 750 mm diameter	a. Dozer, tracked	Trees up to 300 mm diameter.
		b. Tractor with heavy duty winch	
		c. Two tracked dozers with anchor chain	Trees up to 600 mm diameter.
		d. Excavator	
2	Grubbing stumps and clearing roots	a. Dozer, tracked or wheeled	The most efficient attachment is the dozer blade.
		b. Tracked tractor with ripper	
		c. Excavator	
3	Clearing felled timber	a. Dozer, tracked or wheeled	
		b. Dozer with front mounted rake	
4	Clearing boulders	Dozer, tracked	May have to use ripper attachment to loosen boulders.
5	Clearing debris and rubble	a. Dozer, tracked or wheeled	Wheeled dozers are efficient on asphalt or concrete.
		b. Tractor with heavy duty winch	For clearance of large objects.
		c. Loaders, tracked or wheeled	For moving and loading small debris and rubble into haulage vehicles for removal.
		d. Excavator	

Ser	Operation	Heavy Equipment	Remarks
6	Clearing snow	a. Grader	Lanes only.
		b. Loader wheeled	For moving and loading snow.
		c. Dozer, tracked or wheeled	Wheeled dozers for use on asphalt or concrete.
		d. Snowplough or blower fitted to tractor or other suitable vehicle	
7	Stripping - topsoil etc which covers desirable material	a. Dozer, tracked or wheeled	Angledozer for clearing long narrow lanes up to 4 m wide, leaving windrows of material on each side. Slot dozing for more extensive areas, limit 100 m haul. May have to use ripper attachment to break roots and frozen ground.
		b. Scraper, towed or motorized	Haul distance 100-450 m for towed scraper, 300-1500 m for large motorized scraper.
		c. Grader	Only light stripping.
		d. Excavator	Stripped soil hauled away.
8	Earth movement (cut and fill) and embankments	a. Dozer, tracked or wheeled	Optimum haul does not exceed 30 m. Sidehill cuts and cuts down vertical faces for roads.
		b. Scraper, towed or motorized	Towed scrapers are best for hauls 100-300 m and motorized scrapers for hauls 300-1500 m. Pusher required for heavier soils.

Ser	Operation	Heavy Equipment	Remarks
8 (cont)	Earth movement (cut and fill) and embankments (cont)	c. Grader	Suitable for building shallow road embankments not more than 0.5 m high across flat or gently undulating land by cutting longitudinal drainage ditches at each side.
		d. Excavator with face shovel, and haulage vehicles	Suitable for two types of excavation: (1) Where material cast direct from cut to fill, eg, deep side-hill cuts or clearing thick overburden for a road, and (2) Excavation involving long hauls by haulage vehicles, ie, embankments built from distant cuts or borrow pits.
		e. Excavator with backhoe bucket, and haulage vehicles	For bulk excavation below track level. Also for high lifts such as placing in bins of screening plant.
		f. Loader, tracked or wheeled and haulage vehicles	Suitable for short distances, up to 300 m, using 'load and carry', and for loading haulage vehicles for long hauls over 1500 m.
9	Consolidated materials, difficult to dig, eg, hardpan shale and rock All materials must be loosened by rippers or explosive before handling.	a. Dozer, heavy tracked with ripper	Suitable for moving, dumping, and spreading loosened material for hauls of 30-100 m. Used also to stockpile materials.
		b. Excavator with face shovel or backhoe bucket, and haulage vehicles. Rock buckets should be fitted	See Serials No 8(d) and 8(e). Efficiency of these units is much reduced when handling this type of material. Only the larger sizes of excavators are suitable in these conditions. Service excavators are likely to be ineffective.
		c. Scraper with push tractor	See Serial No 8(b). Scraper's efficiency is reduced for this type of material. Special heavy equipment is required.

<b>Ser</b>	<b>Operation</b>	<b>Heavy Equipment</b>	<b>Remarks</b>
10	Ditching - Constructing open ditches for drainage of surface water	a. Grader	Suitable for open V ditches in soil free from rocks and roots.
		b. Dozer, tracked or wheeled	Can cut rough V-shaped or shallow U-shaped ditches.
		c. Excavator with ditch forming bucket	Particularly useful for deep wide ditches, or for clearing or enlarging existing ditches or canals.
		d. Excavator with hydraulic breaker	A heavy hydraulic breaker can also be fitted for breaking out rock in trench bottoms and a grab which can remove broken rock without straddling the trench.
		e. Backhoe	
11	Trenching - Excavating deep narrow trenches with vertical sides	a. Multi-bucket or chain-cutter type trencher	Suitable for soils containing neither large rocks nor roots.
		b. Excavator	Suitable for deeper and wider trenches in heavier soils.
		c. Backhoe	
12	Backfilling - replacing material in a trench or small excavation	a. Dozer, tracked or wheeled	Angledozer best for backfilling trenches. Bulldozer best for pits and other excavations.
		b. Grader	Can be used for side casting windowed material back into an open ditch.
		c. Loader, tracked or wheeled	Useful for backfilling excavations from adjacent spoil dumps.

<b>Ser</b>	<b>Operation</b>	<b>Heavy Equipment</b>	<b>Remarks</b>
13	Sloping and battering - Sloping banks and sides of excavations	a. Grader	Suitable for accurate battering of banks up to heights of 2.5 m.
		b. Excavator	Suitable for cutting back and trimming deep steep faces and for sloping the sides of embankments and excavations.
		c. Dozer, tracked	Can do rough work only. Suitable in cuttings rather than fills.
14	Spreading - Distribution of fill in layers of uniform thickness	a. Scraper, towed or motorised	Suitable for hauling and spreading thin layers of material. For lengths of haul see Serial No 7(b)
		b. Grader	Used for spreading and windowing material of a work-able nature, not containing shattered rock or boulders.
		c. Dump trucks	By controlling the angle of dump and the opening of the tail gate, can spread their loads to a limited extent to assist final even spreading by another machine.
		d. Dozer, tracked or wheeled	Best machine for initial spreading of workable materials, including shattered rock, which have been dumped by haulage vehicles.
15 1	Compaction - Consolidating fill, subgrade, or base course materials	a. Sheepsfoot rollers	Used mainly for compacting cohesive soils of low moisture content. Tamping rollers are now mainly used because sheepsfoot rollers tend to destroy the soil structure.
		b. Pneumatic-tyred roller	Used mainly for compacting fine grained soils, sub-bases, bases and surfaces.

Ser	Operation	Heavy Equipment	Remarks
		c. Steel wheeled roller	Used mainly where crushing action is needed. Also for initial rolling and finish rolling of waterbound macadam, asphalt, and bituminous pavement
		d. Vibrating roller	For compacting non-cohesive soils, sub-bases and bases. It can now be used safely on materials containing up to 50% cohesive element provided water content is not excessive.
		e. Grid roller	Used for compaction of rock and chalk.
		f. High speed compactor	Used for embankments compaction.
		g. Vibrating plate compactors and tampers	Used at sites too restricted for rollers.
16	Cambering, trimming and shaping to formation level	a. Grader	Best machine for final camber. Grader with scarifier used to loosen and shape top layer of an earth road or runway.
		b. Dozer, tracked or wheeled	Can provide camber during initial excavation for road formation, but cannot accurately do shaping.
		c. Scraper, towed or motor	Can form camber during initial excavation, but not shaping.
17	Maintenance of earth haul roads	a. Grader with scarifier	Best machine for this work. Suitable for loosening and shaping top layer of earth road or runway.
		b. Dozer, tracked or wheeled	Should be used only if grader not available.
		c. Loader, track/wheel	
		d. Excavator	For excavation of culverts etc

Ser	Operation	Heavy Equipment	Remarks
		e. Backhoe	
		f. Scraper	Initial use to improve grades.
18	Digging battle trenches and support weapon trenches	a. Backhoe	
		b. Excavator	For larger trenches.
19	Digging field fortifications-shelters/command posts/aid stations	a. Excavator	
		b. Backhoe	For smaller fortifications when excavator not available.
		c. Dozer, track/wheel	Only if excavator not available.
		d. Loader, track/wheel	
20	Digging vehicle emplacements	a. Excavator	
		b. Backhoe	When excavator not available.
		c. Dozer, tracked or wheeled	Used for vehicle emplacements when soil does not have to be removed.
		d. Loader, track/wheel	
21	Digging antitank ditches	a. Dozer, tracked	Best machine. Work in pairs.
		b. Excavator	More productive when working in pairs.
		c. Dozer, wheeled	Only to assist in berm placement.
		d. Loader, track/ wheel	
22	Digging field sanitation facilities	a. Backhoe	
		b. Excavator	

23	Excavating building construction site	a. Backhoe	For small shallow vertical excavation.
		b. Excavator	For deeper vertical excavations.
		c. Dozer, tracked	For large excavations without vertical embankments.
		d. Loader, wheeled or tracked	For loading excavated soil in haulage vehicles.
24	Loading material - debris, rubble, soil, rock and snow	a. Loader, wheeled or tracked	Primary loader of dump trucks.
		b. Excavator	
		c. Backhoe	
25	Lifting - Material lifting and handling tasks	a. Crane	Best for heavy and extended lifting.
		b. Excavator with backhoe bucket	
		c. Loader with forklift attachment	For loading containers and pallets.
26	Pile driving	Crane with pile driver attachment	

Fig 7A-1 Heavy Equipment and Heavy Equipment Tasks