CHAPTER 8

GENERATORS AND POWER DISTRIBUTION

GENERAL

1. The Canadian Forces have several varieties of generators in use for field operations. These generators range from 0.5 to 100 kw and their uses vary from supplying power to vehicle mounted command posts, to lighting static field camps. The general operating instructions, safety precautions and maintenance instructions for generator sets are covered in this chapter. For further instructions, see the specific operator manual and check the plates attached to the machine.

0.5 KILOWATT GENERATOR

2. The 0.5 kw generator is used to supply power to vehicle mounted command posts that have a maximum of two radios. It has the following specifications:

a. gasoline engine - 1½ hp;

b. fuel tank - 4.5 litres;

c. fuel consumption - 2.2 litres per hour;

d. generator - 0.5 kw, 28 volt DC; and

e. crankcase - one litre of SAE 30 (summer) or SAE 10 (winter).

5 KILOWATT GENERATOR

3. The 5 kw generator produces alternating current (AC) which can be used to supply power to a command post complex containing several radios and an internal lighting system. Normal equipment such as florescent lights, photocopiers and refrigerators can also draw power from this generator. It has the following specifications:

a. gasoline engine - 10 hp;
b. fuel tank - 20 litre jerry can or modified 200 litre drum;

c. fuel consumption - 6.5 litres per hour;

d. crankcase - 9 litres of SAE 30 (summer) or SAE 10 (winter); and

e. generator - 5 kw:

(1) volts - 120/240 volt one phase or 120/208 volt three phase,

(2) amperes - 52 amps at 120 volts, one phase; 26 amps at 240 volts one phase; 30/17.3 amps at 120/208 volts, three phase, three wire; and 30 amps at 120 volts three phase, four wire,

(3) kilowatts - 5 kw, and

(4) rpm - 3 600.

10 KILOWATT GENERATORS

Specification	**10 KW Generator**	
	Gasoline Engine	Deutz Diesel
Engine	10 hp gasoline	two-cycle, four-stroke direct injection diesel
Fuel tank	20 litre jerry can or a modified 200 litre drum;	45.5 litres
Fuel consumption	9 litres per hour	0.275 kg per kilowatt hour
Crankcase	9 litres of SAE 30 (summer) or	6 litres: a. -50 to -18°C

Specification	10 KW Generator	
	Gasoline Engine	Deutz Diesel
	SAE 10 (winter)	SAE 5W20 AP1/CC, SF, SE, b. -18 to 0°C SAE 10W20 AP1/CC, SF, SE, and c. 0 to 53°C 3-GP-304M Grade 30.
Volts	one phase 120/240 V and 120 V, and three phase 120/208 V	single phase two wire 120 V, single phase three wire 120/240 V , and three phase four wire 120/208 V.
Amperage	three phase, 34.7 amps per line, one phase 104 amps, and 52 amps on 240 V connection	104, 52 and 35 amps
Kilowatts	10 kw	10 kw
RPM	3600	1800
Phase	one or three phase.	one phase two wire 120 V, one phase three wire 120/240 V or three phase 120/208 V

Fig 8-1 Standard 10 kw Generator Specifications

4. Normally 10 kw generators are used to supply power to large field camps which contain lighting, refrigeration, electric heating systems, and communications, ADP and recreation facilities. They can be skid mounted or trailer mounted for ease of transport.

SAFETY PRECAUTIONS

5. **Safety Precautions.** The following safety precautions are common to all generators, but the operator shal refer to the operator's manual for detail unique to that model:

a. ensure the generator is properly grounded at all times;

b. locate a dry chemical fire extinguisher near the generator to combat fuel and electrical fires;

c. ensure that the generator has proper ventilation and exhaust gases are piped away from the working and living area;

d. shut down the generator and if possible cool prior to refuelling;

e. ensure the generator is as level as possible during operation;

f. do not smoke or use an open flame when servicing batteries because they produce a highly explosive gas;

g. remove all jewelry and metal items before working on electrical equipment;

h. wear ear protectors when operating a generator set;

j. rope off an area around the generator being serviced to protect other personnel;

k. use caution when removing the cap from a radiator that contains hot engine coolant. Rotate it slowly to reduce pressure;

m. do not co-locate material or equipment in the generator trailer as damage and electrical shortages can occur; and

n. leave all maintenance beyond operator maintenance to qualified technicians.

6. During wet and damp conditions, the generator can be dangerous. If a person becomes the victim of electrical shock, **SHUT DOWN** the generator before attempting first aid. If the work area is damp, use insulated materials or a wood platform to avoid serious shocks;

OPERATOR MAINTENANCE

7. The following operator maintenance procedures are common to all generators, but operators shall refer to the manufactuer's maintenance manual for details unique to that model:

a. inspect the generator for leaks, broken, loose or missing parts;

b. check fuel and add as required, ensure no water or dirt enters the fuel tank;

c. inspect and clean the fuel cap and tank screen as required;

d. inspect the fuel filter and sediment bowl at every fill up for accumulation of dirt and water;

e. check the oil level every eight hours, add oil to full mark only. **DO NOT OVERFILL**;

f. inspect and clean the breather relief valve;

g. inspect and clean the air cleaner;

h. inspect for proper grounding at both the grounding rod and ground terminal of the generator;

j. inspect the battery for loose cables, cracks and proper water levels; and

k. during operation, check all instruments and settings for security and proper operation, excessive noise, slowing down of the engine or a strange odor indicating a problem. **SHUT DOWN** and inspect the generator if a

problem develops. If the problem cannot be resolved by the operator, contact a qualified technician.

8. The qualified technician shall:

a. adjust rheostat to obtain selected voltage. If problems occur, check for loose connections and adjust the carburetor;

b. if the percent load meter fluctuates, check for loose connections, then check that the applied load is within 500 watts (0.5 kw), and

c. proceed with appropriate repairs as required.

POWER DISTRIBUTION

9. Power distribution sets are available for field generator sets. The fuse breaker panel works much the same as the breaker panel in a home, allowing for guarded circuits and preventing the circuits from becoming overloaded which causes damage to the generator and components connected to the power source.

CHAPTER 9

RESOURCES

SECTION 1

INTRODUCTION

GENERAL

1. Engineer resources cover a wide range of equipment and materials which are sub-divided into engineer equipment, engineer stores, heavy equipment and defence stores. This chapter deals exclusively with those engineer stores that are used to complete field engineer tasks.

2. The availability and supply of different types of resources varies according to the area of operations. For instance, there is a scarcity of large timber in the sub-arctic area of Canada compared to heavily wooded areas in Northwest Europe. Due to logistic problems, it is often necessary to use less suitable or inferior materials that are found close at hand. For field engineering tasks, planners shall consider the use of local materials, even though this may require design adjustments.

3. This section discusses engineer resources in general, Section 2 deals with small scale logging operations, and Section 3 covers defence stores. Annex A contains tables on the mass of various materials and common Canadian timbers. The safe angle of repose and the bearing pressure of rock and soil is contained in Annex B.

RESOURCE CATEGORIES

4. **Engineer Resources.** Engineer resources is a generic term which includes anything required by engineer units to complete their tasks. The term includes engineer stores, equipment, heavy equipment, and defence stores. It also typically includes labour or manpower and transport integral to engineer units.

5. **Engineer Stores.** Engineer stores are either expendable or recoverable materials that are normally used in engineer tasks. Engineer stores include:

a. culverting;

b. expedient trackway;

c. building materials such as cement, lumber and hardware; and

d. road construction materials such as sand, gravel and asphalt.

6. **Engineer Equipment.** Engineer equipment is tools and implements used repeatedly in engineer tasks but not consumed. For example:

a. camouflet sets;

b. earth augers;

c. concrete breakers;

d. chain saws;

e. compressors, pumps and generators;

f. bridging; and

g. minelayers.

7. **Engineer Heavy Equipment.** Engineer heavy equipment is either self-propelled or towed machinery and attachments which are primarily used by engineers for horizontal and vertical construction. Heavy equipment capabilities and employment is discussed in Chapter 7.

8. **Defence Stores.** Defence stores are non-explosive materials used by all arms in defence works, including:

a. construction wire;

b. concertina and barbed wire;

c. pickets;

d. sandbags; and

e. corrugated galvanized iron (CGI).

NATURAL MATERIALS

9. **Rock**. Types of rock will vary from hard granite to softer materials such as shale and sandstone. For field engineering purposes, rock will be mainly used for tasks such as road and track maintenance or strengthening of entry and exit points for gap crossing sites. Sources shall be selected near work sites to reduce the hauling distance.

10. **Gravel and Sand**. Gravel and sand mixtures found in river beds or beaches make suitable aggregates for concrete but will require the addition of a binder before they are of much value for road construction. Gravel and sand found in natural deposits away from water usually have a clay content and provided that the right amount of water is present, make a good temporary road surface.

11. **Clay**. Pure clay is of little value to the field engineer as it becomes deformed when subjected to a constant load. Clay is useful as an improvised reservoir lining. Do not allow it to become dry and sun baked, or it will crack. These cracks will not close when the reservoirs are refilled.

12. **Turf.** Turf is the top few inches of soil in which grass is rooted. The roots hold the soil together and prevent erosion by wind and rain. Sod is a block of turf cut out of the ground that can be used for concealing excavated soil, or stabilizing embankments. When rolled up carefully, green side inwards, stacked and kept damp in a shady area, sod retains its colour and lives for a considerable period of time.

13. **Large Trees.** Large trees can be used in a variety of engineer tasks such as non-standard bridging, field machines and defensive positions.

14. **Saplings and Small Trees.** Saplings and small trees can be used for corduroy roads and improvised pickets for fencing and anchorages. They can also be used for the revetment of defensive positions, as well as concealing them.

SALVAGE MATERIALS

15. Salvage materials are items removed from demolished buildings and structures. Great care shall be taken, as removal may cause collapsing or detonate booby traps set by hostile forces.

16. Salvage bricks have many uses in field engineering. They are used as aprons for culverts, linings in sharp bends in drains, revetting and when crushed, they provide an excellent road repair material. When laying bricks as a revetment, lay them as sandbags against the soil at a slope of 4 to 1 with each course horizontal and with the vertical joints staggered. When paving, lay them in a level foundation of sand or dry earth and break the joint in all directions.

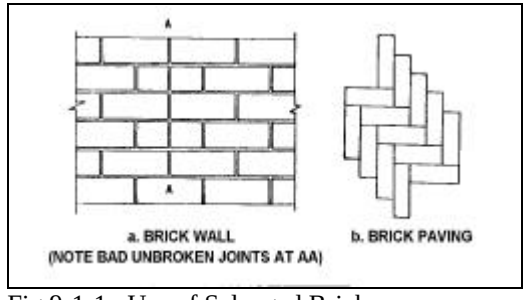

Fig 9-1-1 Use of Salvaged Bricks

17. **Timber.** Timber from wrecked buildings or structures is likely to be damaged. Inspect it carefully before putting it under a load. Check for nails especially when using a chain saw.

18. **Steel.** Recovered steel can be used in construction of improvised bridges and command posts.

19. **Corrugated Iron.** Corrugated iron is generally limited in quantities and a difficult resource to obtain. It shall be salvaged whenever possible.

SECTION 2

LOGGING OPERATIONS

SAFETY

1. Felling timber is the most hazardous part of logging, but other aspects of the job also require care and attention. Personnel will follow the chainsaw safety precautions detailed in Chapter 4.

2. The following precautions should be observed at all times:

   a. work in teams of two or more personnel and coordinate each other's work, between teams and within teams;

   b. maintain a safe distance between felling teams, and pause frequently to check and coordinate each other's progress;

   c. wear all protective clothing and equipment;

   d. select a safe line of retreat from the tree and physically check the route for obstructions such as deadfall;

   e. before making any cuts in a tree, study it carefully for lean, obstructions to the path of fall, loose branches, and the rolling effect of the trunk as it breaks away from the stump;

   f. before trimming a limb from a fallen tree, check that the action will not cause the trunk to roll towards you; and

   g. ever leave a tree partially cut.

3. Always bear in mind that in spite of careful planning the tree may not fall in the desired direction. Plan accordingly.

PREPARATION FOR FELLING

4. **The Lean of the Tree.** If a tree has a lean of not more than five (5) degrees, as evenly distributed branches, and is not being pushed by a strong breeze, it can usually be felled in any direction. Big trees that have

excessive lean or an unbalanced pattern of branches can seldom be fallen in the direction opposite the lean without the use of an aid such as blocks and tackle. However, by use of correct techniques, a tree in these circumstances can be felled as much as 45° either side of its natural lean.

5. **Clearing the Working Space**. Clear brush and small saplings adjacent to the tree to allow plenty of working space and remove low hanging branches.

FELLING TREES

6. **The Scarf (Notch).** The scarf (notch) is the V-shaped cut made in the tree on the side it is to fall. To aid in keeping this cut accurate, draw it with chalk or charcoal on the tree. It should be from 300 mm to 450 mm above ground level unless some obstruction. For example, a large rock, makes this impossible. The notch shall penetrate from one-third to half-way into the tree, depending on the centre of gravity. For a tree with a distinct lean that is being felled in the direction of the lean, a wedge penetrating one-third of the tree is sufficient. Cut to form an angle of about 45°. When cutting a large tree using an axe, the wedge can be formed by cutting two notches and then joining them as shown in Fig 9-2-1.

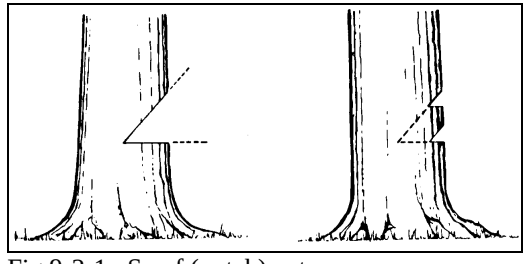

Fig 9-2-1 Scarf (notch) cut

7. **Making the Back Cut.** The back cut is the felling cut and it is made on the side directly opposite the wedge. It should be horizontal and approximately 50 mm above the floor of the wedge as shown in Fig 9-2-2. The back cut should penetrate the tree until about 50 to 80 mm of holding wood is left. This uncut wood is known as the hinge and serves to guide the tree as it falls. The hinge should never be less than 30 mm thick. If after making the back cut, the tree

is still balancing, it should be tipped by driving timber wedges into the back cut. Trees with a diameter larger than the length of the chain-saw guide bar can be felled by consecutive cuts as shown in Fig 9-2-3.

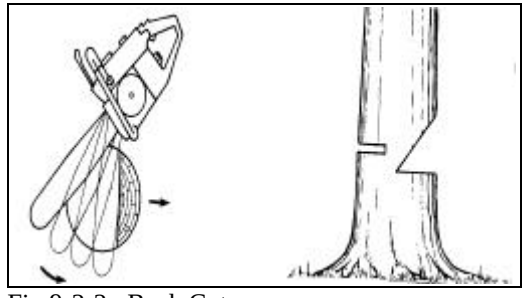

Fig 9-2-2 Back Cut

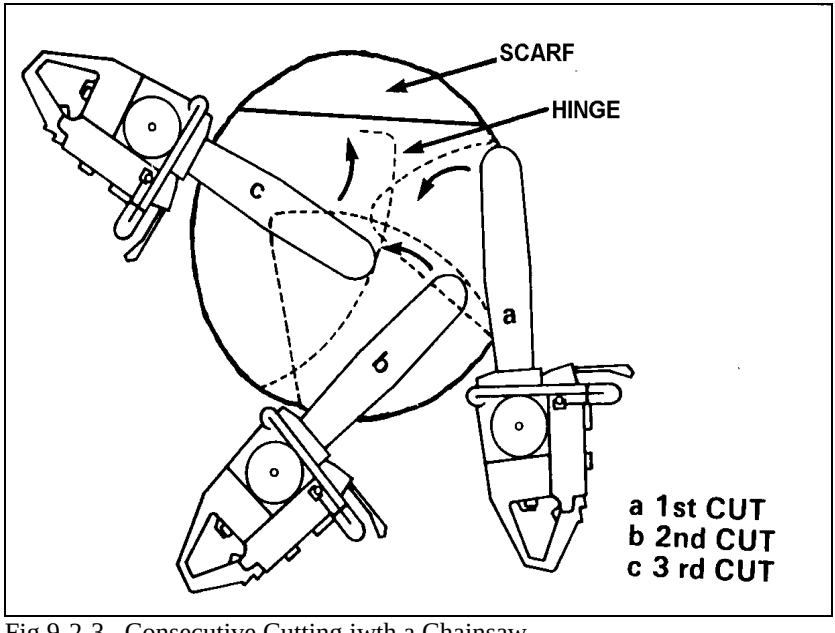

Fig 9-2-3 Consecutive Cutting iwth a Chainsaw

8. **Altering the Direction of Fall.** When a tree leans slightly in a direction different from that which it is required to fall, the direction of fall can be altered to a certain extent by one of the following methods:

a. **Holding a Corner**. Holding a corner involves leaving more hinge wood on the side opposite to which the tree leans when making the back cut. This acts as a

hold back and twists the tree away from the direction in which it leans.

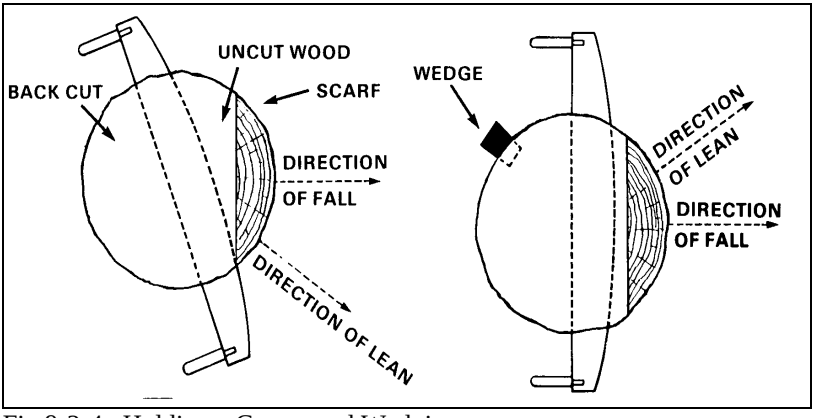

Fig 9-2-4 Holding a Corner and Wedging

b. **Wedging**. One or more timber wedges can be driven into the back cut on the leaning side in order to tip the tree into an upright position from which it can be made to fall in the desired direction.

9. **Felling Against the Lean.** Felling against the lean can be achieved providing the lean is not excessive. The back cut is made first and timber wedges are inserted before the saw blade becomes jammed. Wedging and sawing are continued until the tree is vertical. Once in a vertical position, the scarf (notch) is cut. The back cut is then completed and wedging is increased until the tree falls.

10. **Handling Hung-up Trees**. When working in thickly timbered areas it is sometimes impossible to prevent a cut tree from lodging in a standing one. The safest method of dealing with this, is to use a vehicle winch cable to pull the tree clear. Alternatively, if the tree is lightly lodged, cutting it loose from its stump and prying the butt to the ground may cause the tree to fall. A risky but sometimes unavoidable procedure is to fell the tree in which the first one is hung-up. It is difficult to judge the stresses involved, or the way the two trees will then fall, and this shall only be attempted by experienced tree fellers.

PREPARING THE LOG

11. After the tree has been felled, there are normally three preparatory actions that are carried out before the log is removed from the felling site: trimming, logging-up and de-barking.

12. **Trimming.** The removal of the limbs is known as trimming. Limbs are cut through from the bottom side and as close as possible to the trunk.

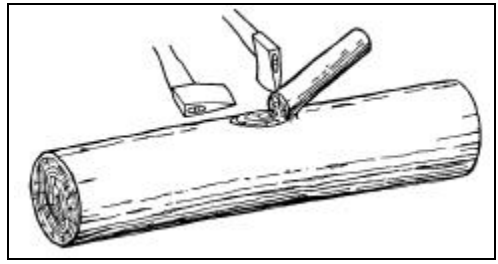

Fig 9-2-5 Trimming

13. **Logging-Up.** Logging up is the process of cutting the fallen tree to its required length.

14. **De-barking**. De-barking is the process of removing the bark to expose the solid timber beneath. On trees with a thick bark, this can be done by cutting a line with the chainsaw or axe along the tree trunk after it has been trimmed. The bark can then be removed by knocking it away with the back of an axe or adze, and then peeled away with the blade.

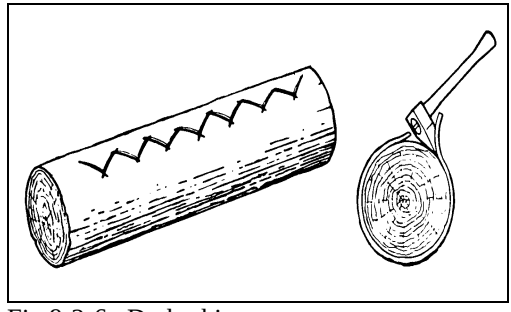

Fig 9-2-6 De-barking

SECTION 3

DEFENCE STORES

GENERAL

1. Defence stores are issued primarily to construct the field defences covered in B-GL-320-007/FT-001. Some details on the use of sandbags, and the cutting and bending of CGI (corrugated galvanized iron)are given in this section as both may be used in many other field engineer tasks.

2. **Sandbags.** Service sandbags are made of hessian or polyethelene and measure 825 mm X 250 mm. They are issued in bales of 1000 weighing approximately 210 kg. Sandbags are used to make repairs to trenches, to completely revet trenches, to reinforce buildings or to build blast walls.

3. **Sandbag Walls.** A sandbag wall will not stand with a vertical face; the wall requires a slope of 4 to 1. Sandbag walls will last longer if they are filled with a mixture of cement and sand at a ratio of 10 parts sand to one part cement. Examples of sandbag walls are seen in Fig 9-3-1and Fig 9-3-2. When building sandbag walls, remember the following points:

a. sandbags are turned inside-out so that the seams are on the inside.

b. sandbags are to be three-quarters full and the necks tied;

c. sandbags are laid in horizontal layers. The first course is laid as headers at right angles to the length of the wall. The second course is laid as stretchers parallel to the wall. Subsequent layers are laid alternately as headers and stretchers. The wall is always finished with headers;

d. joints in adjacent layers are staggered. This will correctly bond the wall;

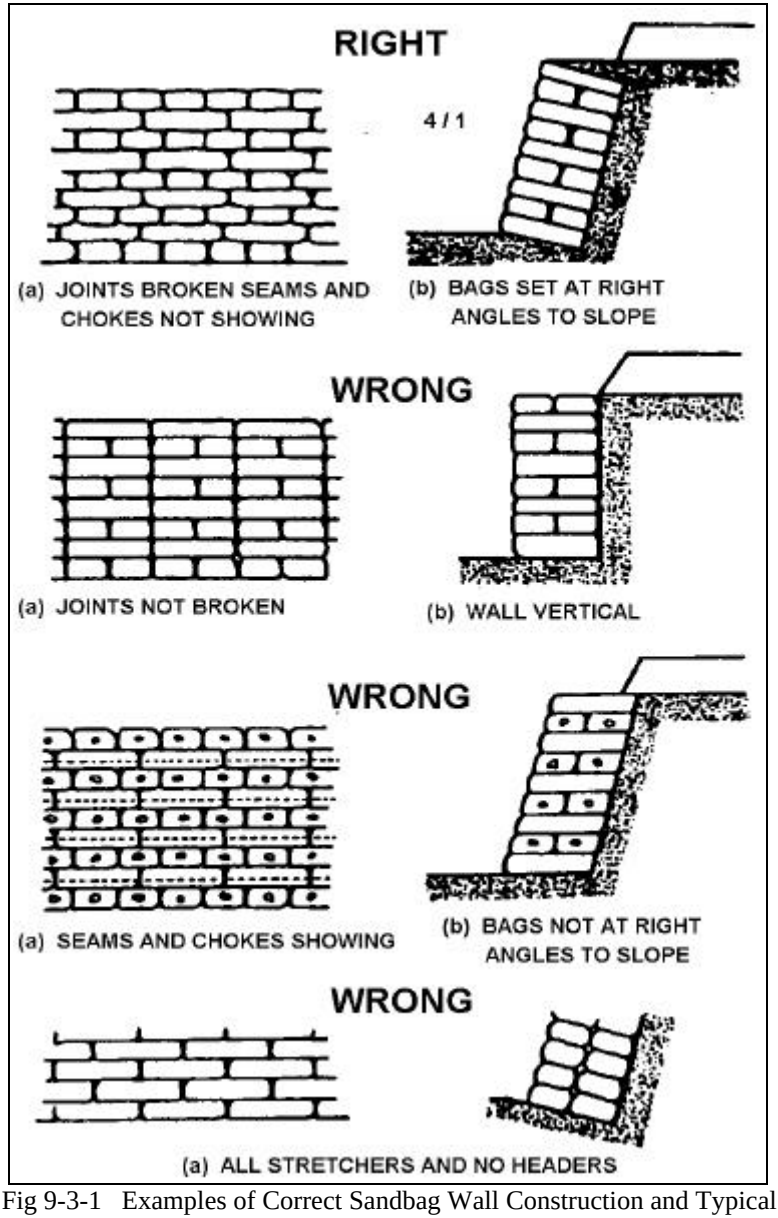

Fig 9-3-1 Examples of Correct Sandbag Wall Construction and Typical Mcistakes

e. because sandbags tend to burst at the seams and necks they are laid so that neither neck or seams are in the outer face of the wall. All corners are tucked in as each bag is laid;

f. after each bag is laid it should be beaten into a standard size and shape with a pick helve; and

g. **Turning a Corner**. Turning a corner involves partially filled sandbags (usually 3/4 filled). The method of turning a corner is shown at Fig 9-3-2.

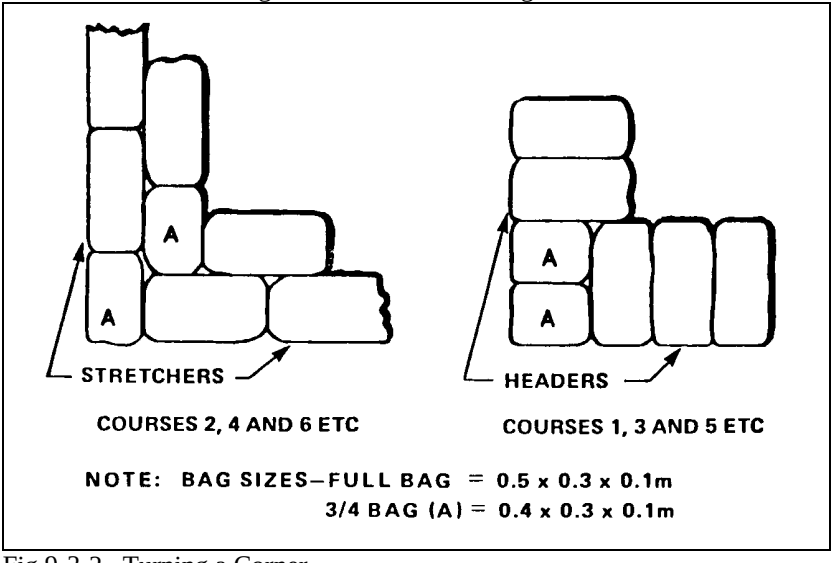

Fig 9-3-2 Turning a Corner

4. **Orgnization of a Sandbag Party**. A party of five soldiers plus the necessary carrying party can fill and lay 60 sandbags in one hour. The organization for building a sandbag revetment is based on the following:

a. one person filling sandbags;

b. two others holding them open and tying the necks as they are filled;

c. two people placing the sandbags at the wall; and

d. a carrying party moving in between.

FREE STANDING WALL DESIGN

5. **Free Standing Walls.** The designs for free standing walls that may provide protection against blast at entrances to shelters, vehicle pits or aircraft bays are shown in Fig 9-3-3. If the wall is more than 1.5 m high, it is better to use one of the designs at (b) or (c) in Fig 9-3-3 rather than making it entirely of sandbags as in Fig 9-3-3 (a).

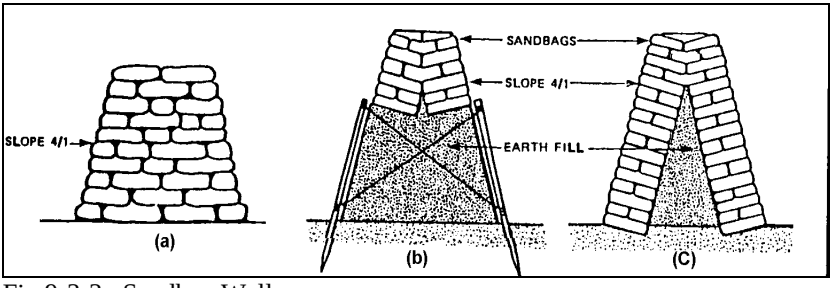

Fig 9-3-3 Sandbag Walls

CORRUGATED GALVANIZED IRON

6. **Cutting CGI.** CGI can be quickly and easily cut in the field by the following method (Fig 9-3-4):

a. anchor two strands of 14 SWG wire about 1.80 m long securely to a picket in the ground and secure the other end to a stick or pick helve;

b. lay the CGI over the wire at the position to be cut and as close to the anchor picket as possible. The edge of the corrugations of the sheet are turned towards the ground;

c. stand on the sheet facing away from the anchor picket with the feet close to the line of the cut and pull the wire upwards, as vertical as possible, using the stick held in the crutch of the arms; and

d. as the wire cuts through the sheet move the feet back along the line of the cut. Do not jerk the wire but apply a steady pull

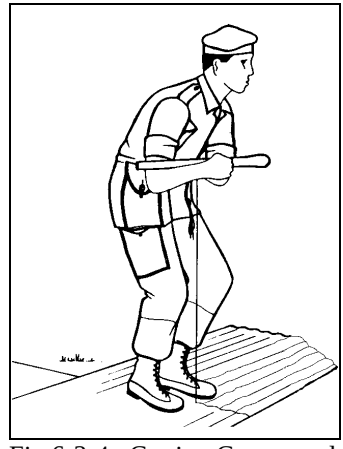

Fig 6-3-4 Cutting Corrugated Iron

7. **Bending CGI.** CGI can be bent across the corrugations as follows (Fig 9-3-5):

a. mark the sheet on both edges and lay an angle iron picket under the sheet along the line to be bent;

b. stand on the sheet to keep it in position and hammer on the corrugations along the picket edge, until a crease appears on the surface of the sheet;

c. reverse the sheet and lay the angle iron picket along the crease mark; and

d. stand on the angle iron picket and raise the end of the sheet to the proper bend. It is easier for two men to do this job. This method will produce a sharp bend that will fit around corners of trenches.

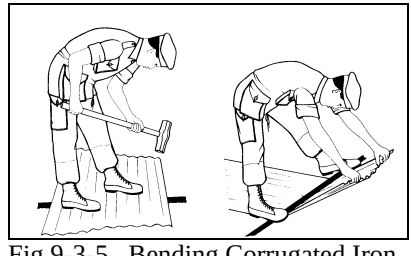

Fig 9-3-5 Bending Corrugated Iron

8. **Fastening CGI.** CGI can be fastened in several ways (Fig 9-3-6):

   a. using nails with lead or rubber washers, to fasten to a timber frame for small building repairs;

   b. wiring together onto timber or struts;

   c. windless back when revetting fire trenches; and

   d. in the case of a buried observation post, setting them into position and backfilling soil so that the pressure holds them in place against the framework.

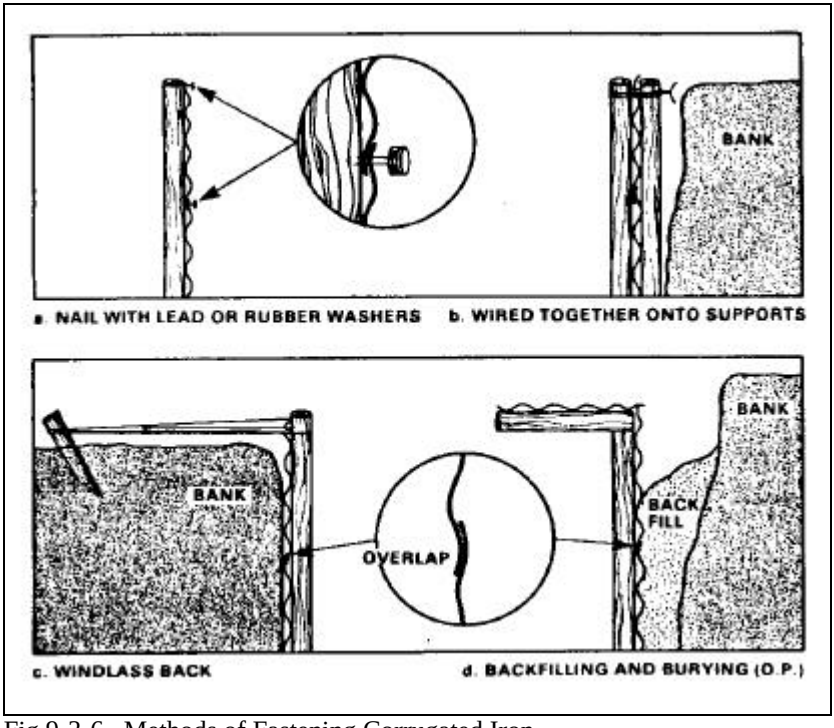

Fig 9-3-6 Methods of Fastening Corrugated Iron

ANNEX A

MASS OF SOME COMMONLY USED RESOURCES

Material	Unit Or Volume	Mass
Blue metal	m^3	2 t
Bricks common	1000	4 t
Cast iron	m^3	7 t
Cast steel	m^3	8 t
Cement	1 bag or $0.02m^3$	40 kg
Cement	25 bags	1 t
CGI (1.8 m)	1 sheet	7.5 kg
Concrete	m^3	2.5 t
Dog spikes	100	50 kg
Earth	m^3	2 t
Fencing wire	Coil (1000 m)	50 kg
Oils (all types)	200 l (drum)m^3	200 kg
Sand, beach, dry	m^3	2 t
Sand, beach, wet	m^3	2.3 t
Sand, river, dry	m^3	1.3 t
Sand, river, wet	m^3	1.5 t
Railway sleepers(Tie)	1	75 kg
Timber iron bark	m^3	1.5 t
Hardwoods	m^3	1.1 t
Soft woods	m^3	650 kg
Water, fresh	1 l	1 kg

Fig 9A-1 Mass of Commonly used Resources

STEEL 'I' BEAMS

Size - Depth X Width		Mass (kg/m)
Metric (mm)	**Imperial (in)**	
610 x 190	24 x 7½	149
560 x 178	22 x 7	112
508 x 165	20 x 6½	97
457 x 152	18 x 6	82
406 x 203	16 x 8	112
406 x 152	16 x 6	74
80 x 152	5 x 6	67
356 x 140	14 x 5½	60
330 x 127	13 x 5	52
305 x 203	12 x 8	97
305 x 127	12 x 5	45
254 x 203	10 x 8	104
254 x 203	10 x 8	82
254 x 114	10 x 4½	37
229 x 178	9 x 7	74
229 x 178	9 x 7	31
203 x 152	8 x 6	52
203 x 102	8 x 4	27
178 x 89	7 x 3½	22
152 x 127	6 x 5	37
152 x 76	6 x 3	18
127 x 64	5 x 2½	13
102 x 76	4 x 3	15
102 x 44	4 x 2	7

Fig 9A-2 Mass of Steel "**I**" Beams

SAWN HARDWOOD

Size -Depth X Width		Mass (kg/m)
Metric (mm)	**Imperial (in)**	
38 x 25	1½ x 1	1.0
50 x 15	2 x ½	0.8
50 x 25	2 x 1	1.4
75 x 15	3 x ½	1.25
75 x 38	3 x 1½	3.8
75 x 50	3 x 2	4.2
75 x 75	3 x 3	6.3
100 x 38	4 x 1½	4.2
100 x 50	4 x 2	5.6
100 x 75	4 x 3	8.4
100 x 100	4 x 4	11.2
125 x 38	5 x 1½	5.3
125 x 50	5 x 2	7.0
125 x 75	5 x 3	10.5
150 x 25	6 x 1	4.2
150 x 38	6 x 1½	6.4
175 x 38	7 x 1½	7.4
175 x 75	7 x 3	14.7
200 x 38	8 x 1½	8.5
200 x 75	8 x 3	16.8
250 x 38	1 x 1	10.6
250 x 75	1 x 3	21.0
300x 38	12 x 1½	12.7
300x 75	1 x 3	25.2
Scaffold planks:		
225 x 32	9 x 1¼	8.0
Note: Assumed mass of 1120 kg per cubic metre		

Fig 9A-3 Mass of Sawn Hardwood

SAWN SOFTWOOD

Size - Depth X Width		Mass (kg/m)
Metric (mm)	**Imperial (in)**	
38 x 25	1½ x 1	0.6
50 x 25	2 x 1	0.8
50 x 38	2 x 1½	1.2
75 x 38	3 x 1½	1.8
75 x 50	3 x 2	2.4
75 x 75	3 x 3	3.6
100 x 38	4 x 1½	2.4
100 x 50	4 x 2	3.2
100 x 75	4 x 3	4.8
100 x -100	4 x 4	6.4
150 x 25	6 x 1	2.4
150 x 50	6 x 2	4.8
175 x 38	7 x 1½	4.3
175 x 50	7 x 2	5.6
175 x 75	7 x 3	8.4
200 x 38	8 x 1½	4.8
200 x 50	8 x 2	6.4
200 x 75	8 x 3	9.6
250 x 50	1 0 x 2	8.0
250 x 75	10 x 3	12.0
300 x 50	12 x 2	9.6
300 x 75	12 x 3	14.0
Scaffold planks:		
225 x 38	9 x 1½	5.5
225 x 50	9 x 2	7.2
225 x 63	9 x 2½	9.0
Note: Assumed mass of 650 kg per cubic metre		

Fig 9A-4 Mass of Sawn Softwood (Pine)

ANNEX B

PHYSICAL CHARACTERISTICS OF ROCK AND SOIL

Type Of Ground	Density (t/m^3)	Safe Angle Of Repose (degrees)	Safe Bearing Pressure (kgf/cm^2)
(b)	(c)	(d)	(e)
Rock:			
Granite[1]	2.7	9.065e+17	20
Shale and Sandstone	2.6		8 - 12
Non-cohesive Soil:			
Well-graded sand gravel[2]	1.9		3 - 4
Poorly graded sand gravel	1.8		2 - 3
Poorly graded sand	1.7		1 - 2
Loose uniform sand	1.6		0.5 - 1
Cohesive Soil:			
Stiff sandy clay and shale[3]	1.9		2 - 3
Firm sandy clay	1.8		1 - 2
Soft clay and silt with organic matter	1.6		0.25 - 0.5

Notes:
1. Allow for faults, cracks and flaking.
2. Use lower figure for uncompacted material or fill.
3. Much affected by water content; use lower figure for wet or undrained soil.

Fig 9B-1 Physical Characteristics of Rock and Soil