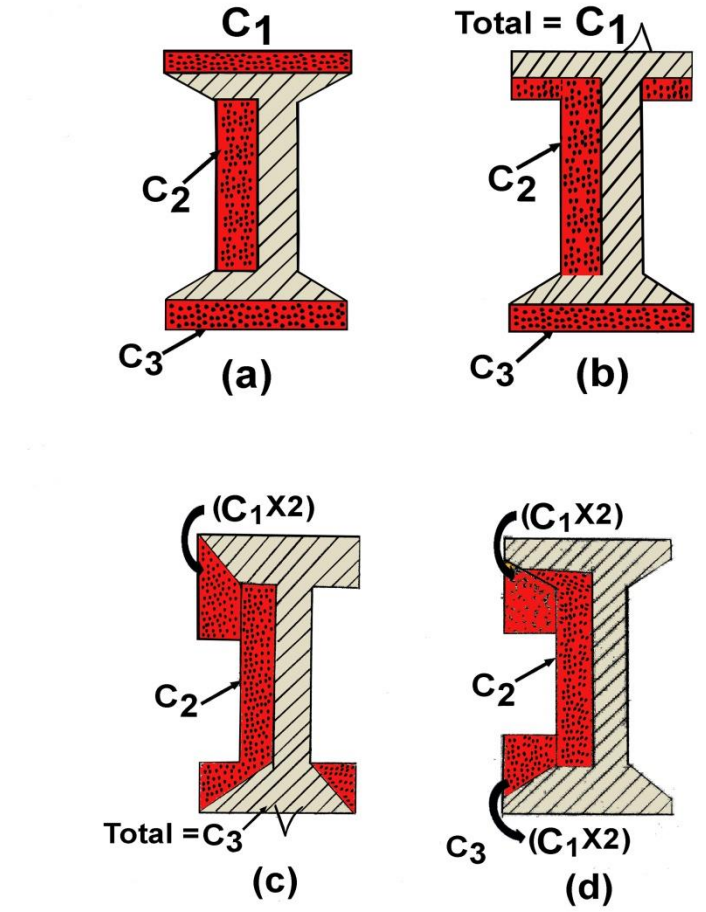
SECTION 6
DELIBERATE CALCUTIONS

0601. In the tables included in this Section the key for formulae is as follows:

b =width of target in ins.
B=width of target in ft.
t=thickness of target in ft.
T=circumference of target in ins.
d=diameter of target in ins.
D=diameter of target or crater in ft or, in extended charges, the width of the crater in ft.

0602. Unless otherwise stated, the calculations are based on the use of plastic PE3A or slab CE/TNT explosives. If others are to be used, adjust in accordance with table 11.

0603. For cutting charges for MS, timber, masonry, and small RC sections, see Table 21, Alternative methods of fixing charges to a built up girder are shown in Figure 6-1. A method of cutting a wooden pile under water is illustrated in Figure 6-2. The charge should be placed against the upstream side of the pile and on the bottom in order to get the full tamping effect of the water. PE3A should normally be used but CE/TNT may be used in an emergency, provided that it is not kept under water for more than 2 or 3 hours before being detonated.



C C2 C3 = Chagres in 1b for top flange, web and bottom flange respectively calculate in accordance with table 21 serial No. 2. If the compression (top) flange plate is more than one inch thick it will not be completely cut if charges are placed as in (c) or (d)

Figure 6-1: Alternative methods of placing charges on I beam

0604. For breaching charge, there is no exact system of calculation and the "hasty" formulae should be used (see Table 15).

0605. For pressure charges, the deliberate formula for a charge for RC beam is:
$C=4H^2T$ lb

where H= the over-all depth from road surface to the bottom of the beam measured in feet, and the minimum values of H and T are 1 ft.

The same rules as given in Table 16 apply. If the charge is shaped to from a prism, with vertical-section an equilateral triangle, enclosing a 4-inch by 4-inch by 4-inch conical air space immediately over the roadway above the beam, the charge can be reduced by one third. Initiation must be at the apex of the triangle (see Figure 6-3). Simultaneous attack on the end of the span on the abutment. or pier (see paragraph 0607) will ensure complete demolition.

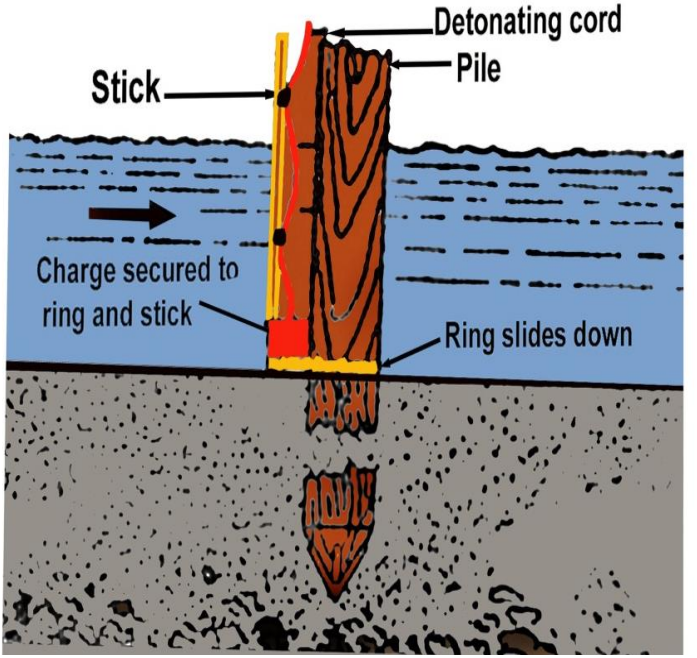


Figure 6-2: Placing pile cutting charge under water

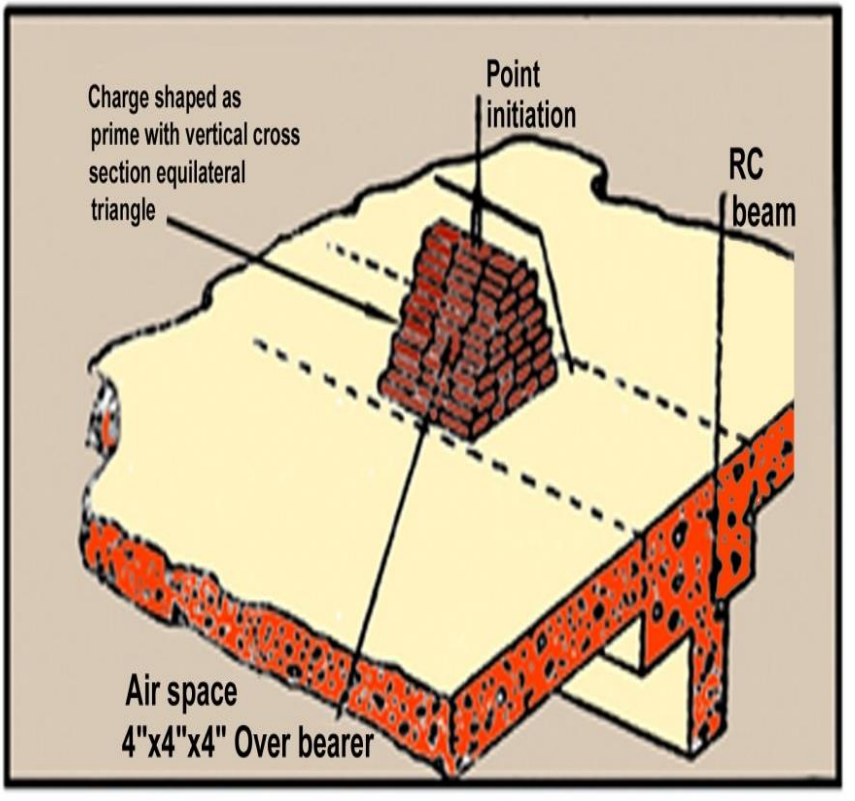


Figure 6-3: Placing pressure charge over R C beam (Tamping omitted for clarity)

Table 21-Cutting Charges for MS, Timber, Masonry and Small RC Sections-Deliberate Formulae

Ser	Target	Weight of explosive (Ib)	Remarks
(a)	(b)	(c)	(d)
1.	Iron or MS round sections	$\frac{d2}{4}$ or $\frac{c2}{32}$	Minimum PE charges is 2 oz
2.	Iron or MS, rectangular sections	$\frac{3bt2}{32}$	Minimum value of t=1 In built-up girders. "t" for a flange is the maximum thickness (plate plus angle iron plus one rivet head) and for web is the minimum thickness (plate only, angle iron and rivets being neglected)
3.	Masonry walls …	$\frac{BT^2}{2}$	B must never be less than the height of the wall. Minimum value for T=1
4.	Masonry piers ..	$\frac{2BT^2}{3}$	
5.	Masonry arch rings	$\frac{3BT^2}{4}$	If attacked from below, T should be doubled to allow for the thickness of the filling above the arch ring. Minimum value for T=1
6.	RC slabs up to 9" thick	$20BT^2$	On typical RC roadway this should cut all mesh top and bottom Minimum value for T=1
7.	RC beams up to 9" thick by 24" deep	$40\ BT^2$	Charges placed on side of beam.

Ser	Target	Weight of Explosive (Ib)	Remarks
(a)	(b)	(c)	(d)
8.	RC girders (for stripping concrete only)	$5HT^2$	In the common type of bridge span, consisting of T section girder with slab over, one-third of the charge should be placed on the road surface and two-thirds against the side of the girder. Reinforcement is cut subsequently as a separate operation
9.	Timber round Sections	$2D^3$	Minimum and maximum values for D=1 and2½ For targets where D is greater than 2½, auger hole charges should be used.
10.	Timber, rectangular sections	$\frac{3BT^2}{2}$	

0606. For footing charges the calculations given in table 17 should be used. Footing charges use three to six times the amount of explosive required for borehole charges, but they can be placed in about half time.

0607. **Mined Charges.**

a. For Cratering roads or airfields see Table 22 and 23.

b. For blowing out brick or masonry abutments or retaining walls and at the same time making a crater behind the length attacked, use the formula:

$$C=\frac{D3}{50}$$

where C= the charge in pounds required to form a crater D feet in diameter.

Consult Figure 6-4 for measurements governing the placing of the charge. The deciding factor when planning the number of charges (n) may be:

(1) L which must be greater than the thickness of the abutment or wall.

(2) H which, in the case of an arched bridge, must bring the charge well below the springing of the arch.

(3) The total weight of explosive, which becomes progressively smaller as n increases.

(4) The time factor. If the nature of the filling behind the abutment or wall permits the use of camouflet equipment, pneumatic drill, or earth auger, a number of small charges will usually be quicker; whereas if a gallery must be driven one large charge chamber will take less time than several smaller ones. For driving a gallery see sub-paragraph d.

c. For simply blowing out brick or masonry abutments and retaining walls without blowing a crater as well, eg, when attacking high walls low down, a number of small charges can be placed behind, and in contact with, the walls by drilling through the face with pneumatic drill or beehive, blowing camouflets, each of 1 to 4 ounces, and then loading the chambers formed with charges equal to $\frac{L3}{8}$ pounds, L being the distance in feet from the outer face of the wall to the centre of the charge. The charges should be spaced 4L/3 feet apart, the outside charges being L feet from the ends of the abutment. The resultant gap should be about 2L wide. All camouflt charges, must be blown together, similarly the main charges. An alternative method is to place a continuous charge in an auger hole close behind, and parallel to, the surface of the wall (see Table 23).

The loading of long holes needs care if complete detonation is to be achieved; one expedient is to bind the detonating cord, with primers every 5 feet, to a bamboo or light wooden bar, mould the plastic explosive round it, and then insert it in the hole. If a Greenlee or equivalent pipe pusher is available the charge can be laid in standard water pipe. Such pipe mines can only be laid in reasonably soft ground; hard chalk, rock,or packed gravel cannot be penetrated. Pipes up to 4 inch diameter can be pushed fairly accurately for 100 feet at a speed of about 30 feet per hour in good ground.

Table 22 – Mined Charges for Cratering-Deliberate Formulae

Ser	Nature of soil	Weight of charge (Ib)	Depth laid below surface (ft)	When target width is too great for one charge	
				No of charges	Spacing of centres (ft)
(a)	(b)	(c)	(d)	(e)	(f)
1.	Rock	$\frac{D3}{50}$	$\frac{D}{3}$	$\frac{4B}{3D}$	$\frac{D}{2}$
2.	Medium or hard soils.	$\frac{D3}{100}$	$\frac{D}{3}$	$\frac{4B}{3D}$	$\frac{D}{2}$
3.	Soft soils or made ground	$\frac{D3}{200}$	$\frac{D}{3}$	$\frac{4B}{3D}$	$\frac{D}{2}$

Table 23-Continuous Extended Mined Charges Using Auger Holes-Deliberate Formulae

Ser	Task	Weight of charge (Ib/ft run)	Remarks
(a)	(b)	(c)	(d)
1	Blowing out masonry abutment or length of revetment	$\frac{L^2}{6}$	L=distance in feet from outside face of wall to centre of hole. Probable width of resultant gap=2L
2	Blowing outside of bank or marking a continuous trench or crater, eg, across a road on an embankment :-		Holes should be driven approximately parallel to surface and at right angles to LLR. If surface is a concrete slab or heavy soling, increase charge by 50 percent. When D^2 formula is used, hole should be at a depth (or with an LLR) of between
	(i) In rock ….	$\frac{D2}{25}$ or $\frac{L2}{6}$	
	(ii) In soft or medium soils.	$\frac{D2}{50}$ or $\frac{L2}{12}$	$\frac{D}{2}$
	(iii) In made ground	$\frac{D2}{100}$ or $\frac{L2}{24}$	and $\frac{D}{6}$, $\frac{D}{4}$ giving best results. The L^2 formula will produce a crater of width 2L.

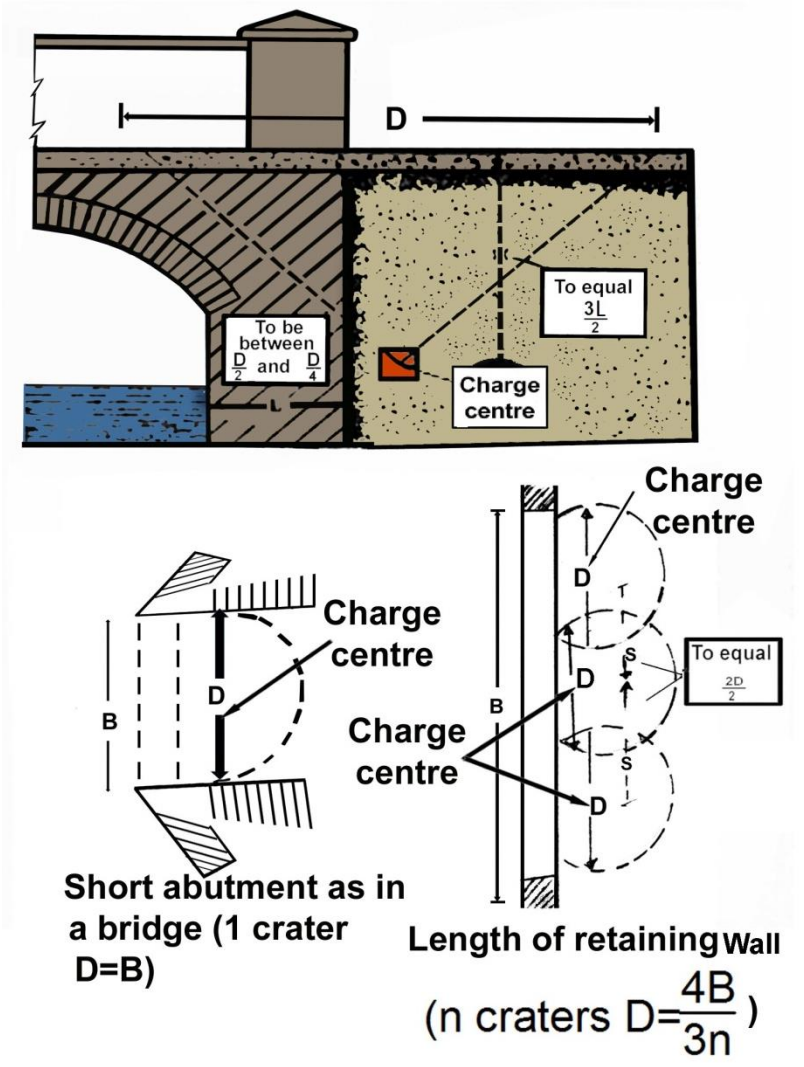


Figure 6-4: Blowing out masonry abutment and forming crater simultaneously (diagrammatic)

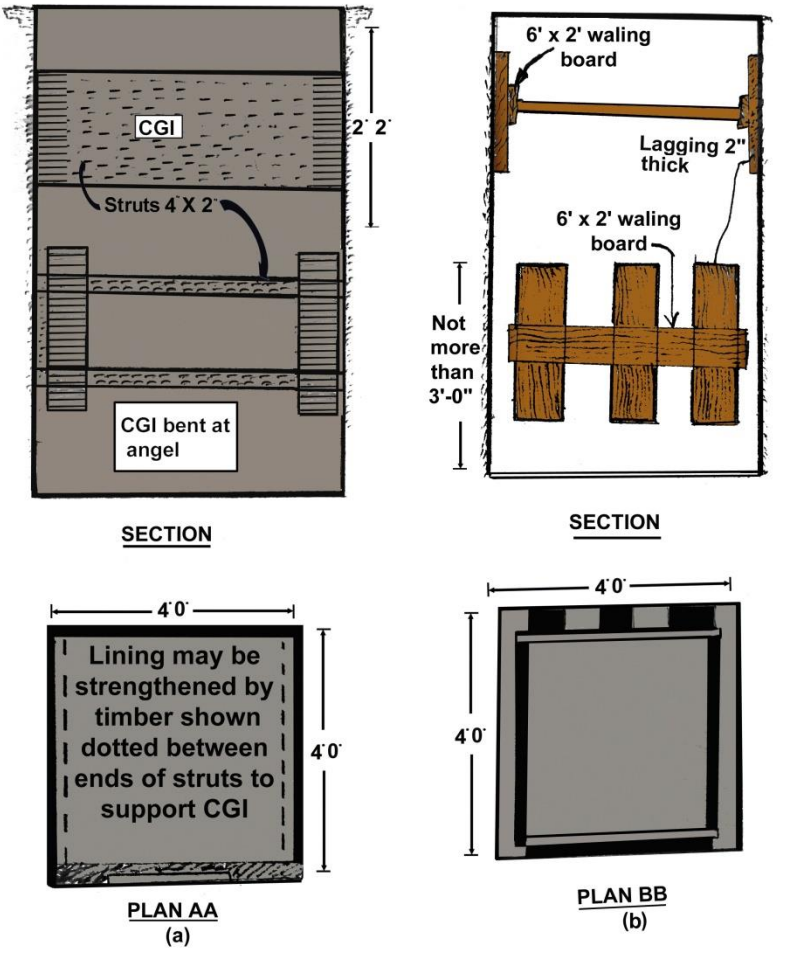
d. If the charge chamber is to be made by mining, either a shaft must be sunk, preferably from a point outside the rim of the crater to be formed or the gallery can be driven straight in at an embankment or escarpment or from a convenient adjacent house cellar. A right angle bend at the end of the gallery must be provided to give tamping. With round-the-clock shift working (3 men per shift) progress in firm soil should be about 10 feet per day in a shaft (4 feet by 4 feet) and 18 feet per day in a gallery (5 feet by 3feet). See Figures 6-5 and 6-6 for methods of shoring temporary shafts and galleries.

0608. For borehole charges use Table 19.

0609. For concussion charges see Table 24. The conditions pertaining to blocked apertures and unbalanced charges as set out in Section 5, paragraph 7, apply. Charges should normally be broken down into lots of 50 to 200 pounds, lots smaller than 100 pounds not being used if wall thickness exceeds 6 feet. If the building will hold water without collapsing and can be filled to three-quarters of internal height a charge of one quarter of serial No.3 in table 24 immersed in the water will destroy the building without debris flying. If depth of water is only one third of internal height, the charge should be equal to one- third of Serial No.3. In the case of light buildings in unrestricted sites tamping charges can be used instead of solid tamping in order to save time and labour.
The tamping charges can be calculated from the formula:

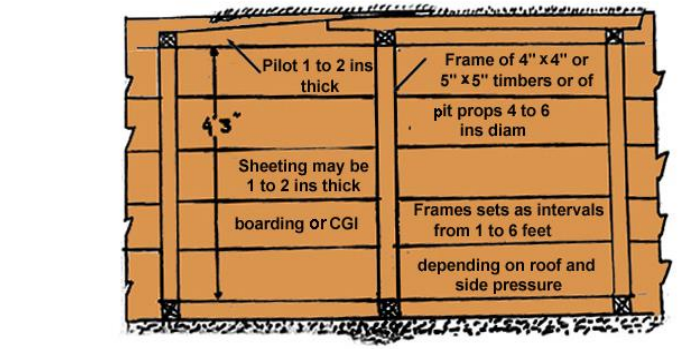
$$T = 5 \times \frac{A1}{A2} \times C$$

Where T is the weight of the tamping charges in pounds, A1 and A2 are the areas of the opening and of the roof walls, and floor of the building, respectively, both in square feet and C is the weight of the main charge in pounds.
Suspend the tamping charge in the centre of the opening (in the case of large openings break the charge down into parcels of 10 pounds and suspend in a pattern)and fire simultaneously with the main charge. Beware of the blast that comes from the opening.

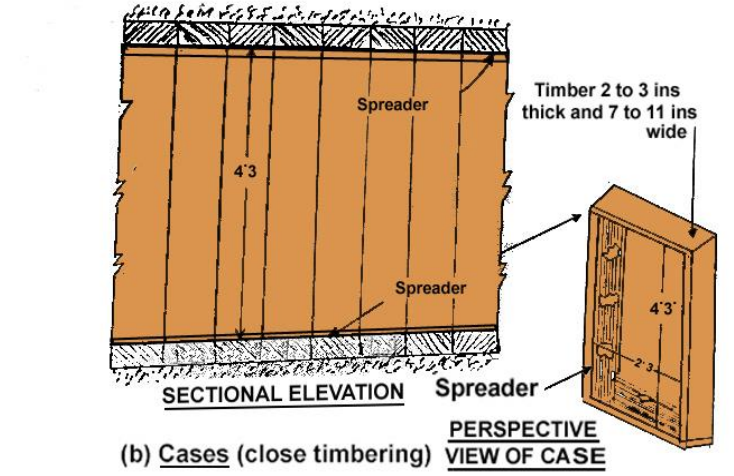


Note Successive sets placed in alternate directions interval between sets spacing of logging and dimensions of timber dependents on suture of ground sets in (b) can overlap

Figure 6-5: Two methods of shoring temporary shaft



(a) Frame and sheeting



(b) Cases (close timbering)

Figure 6-6: Timbering for temporary gallery

Table 24- Concussion Charges-Deliberate Formulae

Ser	Nature of structure	Weight of charge (Ib)	Remarks
(a)	(b)	(c)	(d)
1	Building of CGI, timber, brick or masonry	$\frac{VT}{100}$	V in SerialNo.1 and 2 = internal volume in cuft of ground floor, including party walls. V in serial No.3= internal volume, in cuft of whole structure including party walls, floor etc. T= maximum thickness of wall in feet unless, in Serial No. 3 the roof thickness exceeds that of walls and also one-third of internal height, in which case T= thickness of roof K= factor obtained from Table 25.
2	Building of light RC	$\frac{2VT}{100}$	
3	RC defences …	$K\sqrt{T}\,VT$	

Table 25-Values of K in Calculating Concussion Charges for Defence Works

Ser	Type of structure	Value
(a)	(b)	(c)
1.	Brick structures up to 1,000 cuft internal volume with RC roofs up to 2 ft thick (surface or semi-buried types)	0.1
2.	Brick structures of larger internal volume than in serial No.1	0.2-0.4
3.	RC air raid shelters(surface or below ground with not more than 5 ft cover)	0.4
4.	RC tunnels in normal soil (calculate charges for each 100 ft run)	1.0
5.	RC fortifications with walls up to 2 ft thick and light reinforcement	0.4
6.	RC fortifications with walls 4 ft thick and heavy reinforcement.	1.1