SECTION 24

PROTECTIVE WORKS

Object

2401. UXBs may fall in places where their subsequent explosion would cause damage to vital buildings, fortifications installations or services. Such bombs cannot always be disposed of or made safe immediately but certain measures can be taken by the troops on the spot to minimize the effect of explosion. Protective works may also be used to lessen damage when a UXB is to be demolished in situ or where it is necessary to decrease the area of evacuation.

2402. When deciding if protective works are needed, it is necessary to make an appreciation of the damage the bomb is likely to cause should it explode. Paras 3, 4 and 5 below are intended to assist in making this appreciation. Paras 6 to 11 give details of the forms of protection used.

PROBABLE EXTENT OF DAMAGE IF BOMB EXPLODES

Damage Caused by Blast and Splinters

2403. a. **To Brick Built Houses**. Table 5 gives the maximum distances from an unburied bomb at which unshielded houses with 9-inch brick walls are likely to sustain varying degrees of damage.

b. **To Steel Framed Structures**

(1) **Steel Work**. The steel frames themselves are unlikely to be damaged more than a few feet outside the crater area (Table 9).

(2) **Brick or Reinforced Concrete Panel Walls in Steel Framed Structures**. Table 6 gives the distances at which not more than slight damage will be done to unshielded wall panels in steel frame structures by and unburied bomb.

TABLE 5 - DAMAGE TO BRICK BUILT HOUSES (UNBURIED BOMBS)

Type of missiles	Total weight	Compete demolition or damaged beyond repair	Uninhabitable but repairable	Slightly damaged. Inhabitable
(a)	(b)	(c)	(d)	(e)
	lb	ft	ft	ft
Penetration and general purpose bombs	100	20	40	200
	500	60	120	600
	1000	95	190	950
	2000	140	280	1400
	4000	290	580	2900
Blast bombs and sea mines	1000	140	280	1400
	2000	250	500	2500

TABLE 6 - DAMAGE TO WALLS IN STEEL FRAMED STRUCTURES (UNBURIED BOMBS)

Type of missiles	Total weight	Brickwork and cement mortar				Reinforced concrete wall			
		$4\frac{1}{2}$ in	9-in	$13\frac{1}{2}$ in	18 in	6-in	12-in	187-in	24-in
(a)	(b)	(c)				(d			
	lb	radius		in	ft	radius		in	ft
Penetration and general purpose bombs	100	51	26	17	13	8	5	3	$2\frac{1}{2}$
	500	155	78	52	39	26	13	09	06
	1000	240	120	80	60	40	20	13	10
	2000	360	180	120	90	60	30	20	16
	4000	750	750	375	185	125	62	41	29
Blast bombs and sea mines	1000	555	175	120	89	59	30	20	16
	2000	615	305	205	155	102	51	34	25

Damage Caused by Earth Shock

2404. a. **To Brick Built Houses**. Table 7 gives the maximum distances from a buried bomb at which house with 9-inch brick work will sustain varying degrees of damage.

TABLE 7 - DAMAGE BRICK BUILT HOUSES (UNBURIED BOMBS)

Total weight of bomb	Complete demolition	Damaged beyond repaid	Uninhabitable but repairable
(a)	(b)	(c)	(d)
lb	ft	ft	ft
100	12	23	50
500	22	44	70
1000	35	70	100
2000	60	120	200
4000	120	200	400
8000	200	300	550
12000	250	400	700

b. **To Underground Services and Structures**. Table 8 gives the maximum distance at which underground services and foundations are likely to be damaged.

TABLE 8 - DAMAGE TO UNDERGROUND SERVICES AND FOUNDATIONS (BURIED AND UNBURIED BOMBS)

Total weigh of bomb	Cast-iton or concrete pipes		Earthenware of brick sewers		Electric cables and steel pipes		Foundations	
	Unburied	Buried	Unburied	Buried	Unburied	Buried	Unburied	Buried
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
lb	ft	ft	ft	ft	ft	ft	ft	ft
100	20	26	30	40	15	20	35	50
500	30	40	50	65	24	30	75	100
1000	35	50	60	80	27	35	150	150
2000	50	65	90	120	38	50	165	250

Crater Dimensions

2405. To site protective works it is often necessary to know the probable radius of the crater which will be formed should explosion occur. Table 9 line (1) gives the maximum radii of the craters to be expected for buried UXBs. To apply these figures the line (2) make allowance for the offset and therefore represent the maximum distances from the entry hole at which the edge of the crater is likely to be formed.

TABLE 9 - MINIMUM DISTANCES FOR SITING PROTECTIVE WALLS AND TRENCES (BURIED BOMBS)

Total weight of bomb in pounds	100	500	1,000	2,000	4,000	12,000	22,000
(1) Radius of actual crater in feet	10	17	23	28	37	52	62
(2) Maximum distance of crater edge from entry hole allowing for offset in feet	28	37	43	54	73	100*	120*

Notes: (1) Figures marked * are estimated only.

(2) Crater radii are for clay soil. Dimension in chalk, sand and gravel may be only 3/5 of the figures given.

FORMS OF PROTECTION

Protective Walls

2406. a. **Purpose**. Protective walls deflect the blast harmlessly upwards and stop bomb splinters and secondary debris.

b. **Siting Walls**. May be used either inside or outside buildings. they should be sited a few feet outside the probable crater (Table 9) and never within it. The length of the wall should be adjusted to suit the object to be protected.

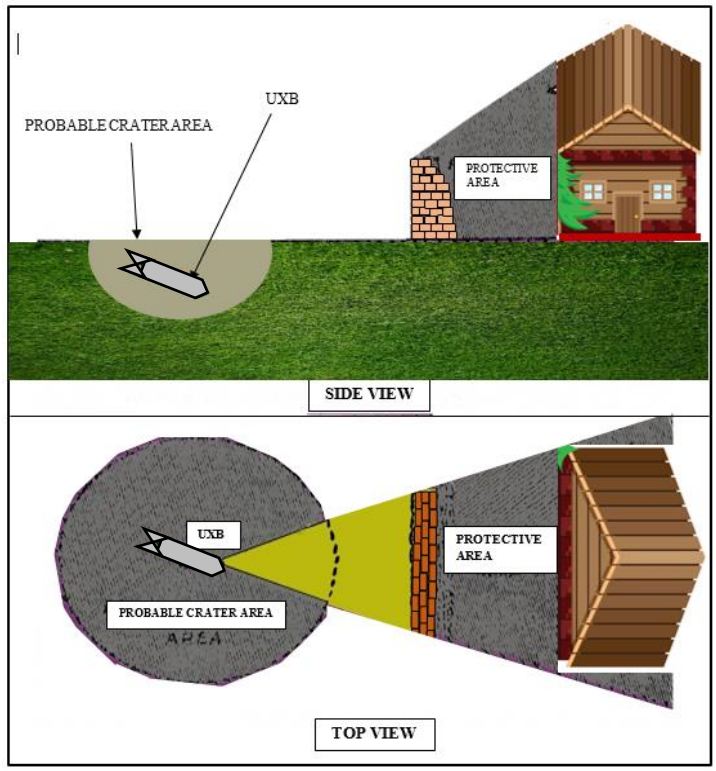

Fig 24-1: Siting a Protective Wall

c. **Sandbag Walls**. Protective walls are usually built with sandbags (Fig 24-2). The base should be at least four feet two inches wide, the height at least ten feet and the outer surface of the wall should slope at 6/1 (the size of the standard sandbag when filled is 20 inches X 10 inches X 5 inches). The bags must be interlocked or bonded like brickwork.

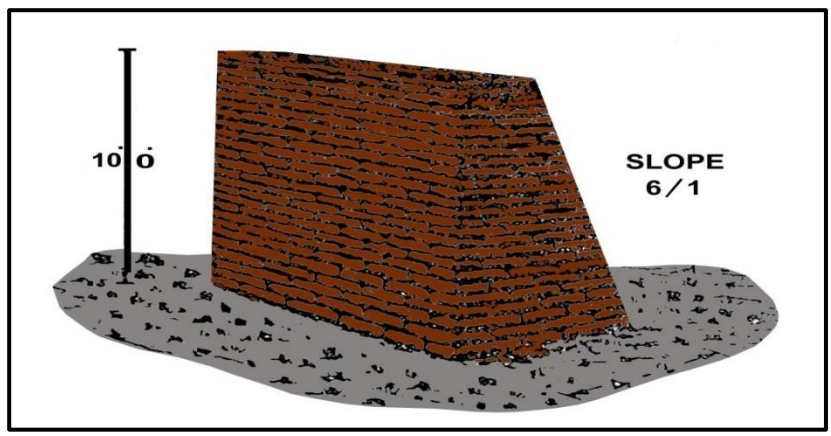

Fig 24-2: Sandbag Protective Wall

d. **Earth Walls**. Where speed is vital and a bomb disposal officer sanction the use or earth moving machinery the wall may be made of loose earth. It should be made so that when the soil settles to its natural angle of repose the wall will remain at least 12 feet high. Such a wall is less compact than one constructed of sandbags and is less satisfactory.

e. **Improvised Walls**. In certain circumstances it may be found convenient to improvise with loaded railway wagons, shells of knocked-out tanks or similar devices. Loaded railway wagons are particularly useful if essential rail traffic is endangered. If they are placed on the side nearest the bomb it may be possible to use the other tracks.

Protective Trenching

2407. a. **Purpose**. Trenches provided the simplest and most effective protection against earth damage. They are used to protect underground probable carter area and which are not buried too deeply.

Fig 24-3: Trench Protecting an Underground Basement

b. **Method**. The trench should be dug near to the object to be protected and at least two feet deeper. It may be as narrow as convenient for for construction. But there must be no cross bracing or strutting which would transfer the slock across the the trench.

Sandbag Abutments

2408. a. **Purpose**. Sandbag abutments are used to protect foundation and walls against earth shock where the bomb is too close or too deep for trenching to be used.

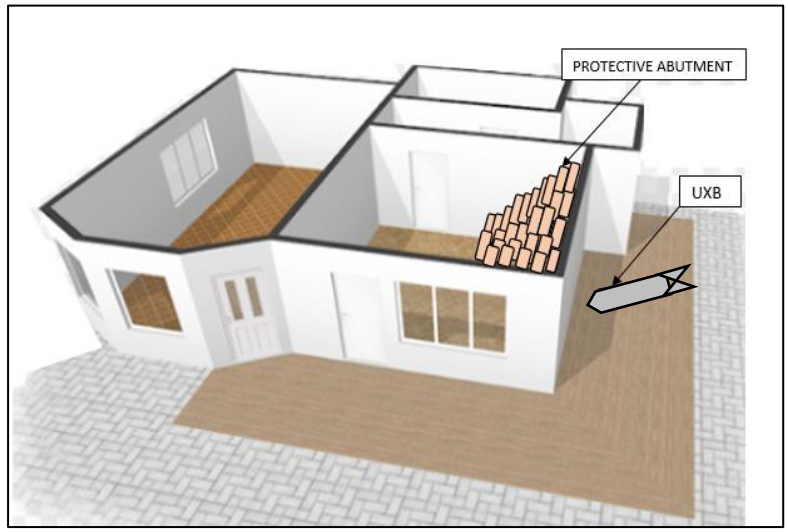

Fig 24-4: Protective Abutment

b. **Method**. Sandbags are built in the internal space against the outer wall. The abutment should be as massive as possible and extend at least ten feet into the room, but on no account must it touch any other load bearing wall or the ceiling. It would then merely transmit the shock through the building. The bags must be interlocked or bonded like brickwork.

Protective Venting

2409. a. **Purpose**. Vents are used when it is vitally important to diminish earth shock but where the effects of blast would not be serious. For example, when railway lines, bridge abutments, dams and underground services are threatened. The method will normally only be of use for bombs which are buried a few feet.

b. **Method**. The method is to dig down and thus create an unburied bomb. An accurate estimate of the position of the bomb is essential. Venting is a difficult operation and should not normally be attempted without RE supervision.

The vent must be either reverted, or dug so that the earth may lie at its natural angle of repose. On no account must the hole be allowed to collapse. The movement or the force of impact of a large quantity of falling earth might cause even a quite insensitive fuze to function. It is most unlikely that the use of mechanical earth moving or excavating equipment will be permissible and it should, on account, be employed without reference to a Bomb Disposal officer.

Protective Mounds

2410. a. **Purpose**. To drive the effects of explosion underground. Protective mounds are used when the effects of earth shock are acceptable but the effects of blast must be eliminated as with a UXB near a road or under an airfield.

b. **Method**. Large quantities of soil are piled over the bomb in the form of a cone. The soil may be loose or in sandbags. Loose blocks of wood, masonry or similar materials must not be used.

c. **Buried Bombs**. With a buried bomb the intention is to form a camouflage and the weight of soil given in Table 10 are sufficient to do this. For bombs heavier than 500 lb, the quantities required, make the method prohibitive unless mechanical equipment can be used. No quantities have been calculated for bombs over 1,000 lb. It is assumed that the bombs have penetrated to the average depth for their size.

Fig 24-5: Protective Mounds

TABLE 10 - REQUIREMENTS FOR PROTECTIVE MOUNDS (BURIED BOMBS)

Total weight of bomb in pounds	soil in which buried	Weight of soil required in tons	No. of sandbags required	Dimensions of cone in feet	
				Diam	Height
(a)	(b)	(c)	(d)	(e)	(f)
100	Clay sand	40 60	1,600 2,400	20 24	6 6
500	Clay sand	125	5,000 7,200	40 40	6 9
1,000	Clay sand	270 400	Only practicable if mechanical equipment can be used	46 50	9 10

d. **Unburied Bombs**. Splinters can be stopped and blast effects greatly minimized by covering unburied bombs up to 500 lb in weight with the quantities of sand given in Table 11. When the bomb is lying on or very near the surface a strong bridge should be built over it first lest the fuze be sensitive enough to operate under the additional pressure or because of movement caused by earth settlement.

TABLE 11 - REQUIREMENTS FOR PROTECTIVE MOUNDS (UNBURIED BOMBS)

Total weight of bomb in pounds	Weight of soil in tons	Number of sandbags	Dimensions of cone in feet	
			diameter	height
(a)	(b)	(c)	(d)	(e)
100	40	1,600	20	6
500	90	3,600	20	6

Protective Surrounds

2411. a. **Purpose**. To provide protection against and to prevent interference with small missiles up to about five Ib in weight such as unexploded butterfly bombs and explosive incendiary bombs, when they are lying on the surface.

b. **Method**.

(1) Protection against blast and splinters is given by a square surround consisting of 80 sandbags constructed as in Fig 48B. The surround is sited with the explosive portion of the missile in the center. The bags must be carefully laid and tightly packed. No gaps must be left through which splinters could pass. If vertical as well as lateral protection is required the surround should be covered with sandbags laid on boards. Should the bomb explode the sandbags are liable to be thrown up to 15 feet away.

(2) When a number of bombs have to be dealt within a small area it is advisable to construct only the inner wall of 32 bags (Fig 24-5A) in the first instance and return to complete the work as time and labor permit. The 32-bag surround provides reasonable protection for troops working on neighboring bombs. It will stop the majority of the splinters.

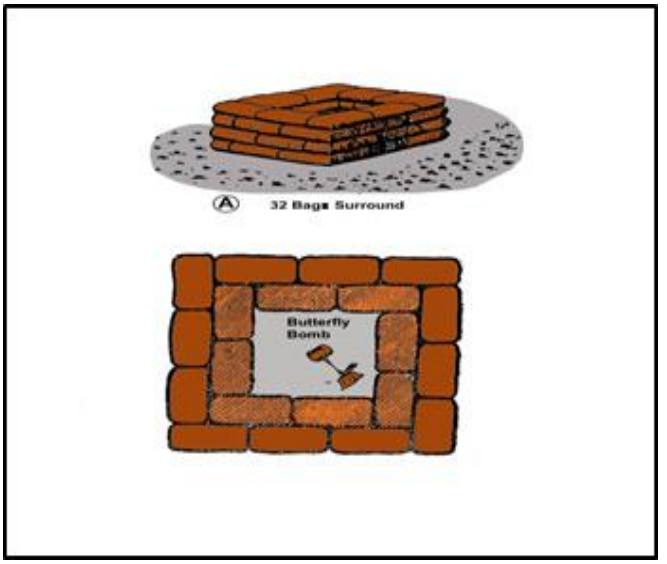

Fig 24-6: Protective Surround

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